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URINARY
ANALYSIS AND DIAGNOSIS

BY MICROSCOPICAL
AND CHEMICAL EXAMINATION

BY
LOUIS HEITZMANN, M.D.
NEW YORK

With One Hundred and Eight Original Illustrations

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CARL HEITZMANN, M. D.

WHOSE LIFE-WORK WAS DEVOTED
TO THE
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PREFACE

In adding another to the long list of works on the examination of urine, the author has been guided by the fact that microscopical examination, and especially microscopical diagnosis, have not received as much attention in the text-books as their importance calls for, while chemical analysis has been thoroughly treated in a large number of works. Many years of experience and teaching have shown him that correct diagnosis by means of microscopical examination of urine can frequently be made in cases where chemical analysis is of little value.

The work is divided into three parts: First, Chemical Examination; second, Microscopical Examination; and third, Microscopical Diagnosis. The first part is short, and only the simplest and most important tests, which alone can be carried out by the busy practitioner, are given, although care has been taken to omit none of great importance. This subject has been excellently treated by many authors, among whom Tyson, Purdy, and von Jaksch may be mentioned, and in many larger works, which should be referred to when more complicated chemical tests are required.

In many cases in which the clinical symptoms, although pointing to an affection of the genito-urinary tract, are vague, and, even with the aid of chemical analysis of the urine, will not admit of a positive diagnosis, microscopical examination, if carefully conducted, will completely clear up the case. It is evident that a mere description of the features found in different cases can not be sufficiently clear, but that illustrations made directly from nature are absolutely essential. In the present volume all the illustrations, without exception,

have been drawn by the author directly from specimens in his possession.

In the third part, devoted to Microscopical Diagnosis, full page illustrations have been added to elucidate the text, each drawing giving the features found in the case it illustrates. As the subject is of the greatest practical value, the author hopes that this volume may serve a useful end, and will consider his labors amply rewarded if he has thereby succeeded in simplifying this extremely important branch of Microscopy.

LOUIS HEITZMANN

NEW YORK, February, 1899

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URINARY ANALYSIS AND DIAGNOSIS

INTRODUCTORY

URINARY ANALYSIS, in order to be thorough and of practical value, must necessarily be both of a chemical and a microscopical character. Chemical examination, although of great importance, can, alone, never lead to a correct diagnosis, as it is only through the use of the microscope that the nature of the disease in the genito-urinary tract, as well as its exact location, can be revealed. Every urine to be examined should, therefore, be first subjected to different chemical tests, the extent of which will vary with the different cases, and then to a microscopical examination.

As a rule, the simpler chemical tests alone will be required. These must be made, first, with a view of determining the normal constituents of the urine; and, second, for the purpose of learning of the presence of any abnormal constituent. A general knowledge of the normal constituents is, therefore, necessary, and we must not lose sight of the fact that these may vary to a considerable degree, even in perfect health, partly from the diet, and partly by conditions of rest or activity. An increased or diminished amount of any ingredient does not necessarily mean a pathological condition, although when this increase or diminution lasts for a long time a diseased condition becomes certain.

In selecting a specimen for examination, it is undoubtedly best to obtain samples of urine passed during the whole twenty-four hours, wherever this is possible; the more so since the quantity voided is important in diagnosing different affections. When this is not practicable, the most concentrated urine, which is usually that first voided in the morning, should be obtained, although different pathological ingredients, such as albumin, may be absent in the morning and yet present in

varying amounts at other times, especially after meals; so that, if any doubt remains as to the exact condition, two samples, passed at different times, must be tested.

Care should be taken that the bottles in which the urine is kept are scrupulously clean and well corked, and that the urine be obtained in as fresh a condition as possible. When the whole twenty-four hours' urine is collected, the bottle should be kept in a cool place and the urine poured into it as soon as possible after being voided. Even then, secondary changes can not always be guarded against. In cold weather such changes will usually not take place for many hours, but in warm weather decomposition is apt to set in at the end of a few hours, and bacteria develop in varying numbers. When not absolutely necessary, it is not advisable to add any preservative to the urine until after the chemical tests have been made. Extraneous subjects can easily find their way into the urine when care is not exercised as to cleanliness, and these not infrequently lead to confusion in examination.

When urine is received for examination, it should be set aside for at least six hours, that a sediment may be deposited, unless it is preferred to use the centrifuge, when examination can proceed at once. In the former case the upper part of the urine is used for chemical tests, and the sediment for microscopical examination; while in the latter, a small amount is used for the centrifugal apparatus, and chemical examination can at once be conducted with the remainder.

After determining the amount of urine voided in twenty-four hours, we must note the color, transparency, and reaction, and carefully determine the specific gravity. By the amount of urine voided, and its specific gravity, we can, in many cases, ascertain if its chief organic constituent, urea (which forms about one-half of all the solid ingredients of urine), is above or below normal; but if the approximate amount of urea is desired, chemical tests must be resorted to.

The next step should always be to determine the presence or absence of albumin, as well as its approximate amount, and by boiling the urine an increase of phosphates at once becomes apparent. Whenever the specific gravity is above normal, or any clinical symptoms lead to a suspicion of the presence of sugar, even at a low specific gravity, tests for sugar must be resorted to. Should it be desired to know the approximate

amount of chlorides, phosphates, and sulphates present (though this is not always necessary), the simpler tests for these salts will, as a rule, be all that are required.

Before resorting to microscopical examination, the nature of the sediment, whether it is present in small or large amount, its color, and its general character should be noted, and then all the elements found under the microscope, as well as their comparative number, should be carefully observed. It will always be safest to examine a number of drops before coming to a conclusion and determining upon the diagnosis.

Part First

CHEMICAL EXAMINATION

Part First

CHEMICAL EXAMINATION

Chapter I

GENERAL PHYSICAL AND CHEMICAL PROPERTIES

Normal urine is a yellowish, transparent liquid, of a peculiar odor and, usually, of an acid reaction, though the latter may be either neutral or slightly alkaline, according to the influence of diet. The average amount passed in twenty-four hours is between 50 and 60 ounces, or 1,500 and 1,800 cubic centimeters, and its specific gravity varies from 1.015 to 1.025.

In determining the exact color and specific gravity of urine, it is of great importance to have the entire quantity passed in twenty-four hours, since both color and specific gravity may vary considerably at different hours. As a rule, the more highly colored the urine, the higher is its specific gravity. The color may vary from an extremely light yellow to a dark yellow, or even a reddish hue.

The amount of urine voided is greatly influenced by different factors. It is greater the more liquid is taken into the body, and as the amount of solids, which determines the specific gravity, usually remains about the same, it follows that the specific gravity will be lower, the greater the quantity voided. The amount of the perspiratory excretion, too, has a great bearing upon the quantity of the urine, and in cold weather, when the perspiration is lessened, the urine increases in amount. Different articles of diet, such as tea and coffee, undoubtedly stimulate the excretion of urine. Nervous excitement, anxiety, and hard mental work have the same effect. Bodily exercise, though increasing the quantity of excreted salts, does not increase the watery constituents of the urine. The

specific gravity of urine voided at different hours of the day may, therefore, vary to a great degree, sometimes being as low as 1.002 or 1.003, and at other times 1.030, without indicating, in any manner, a pathological condition.

Consistency and odor.—Normal urine is of a watery consistency, and foams if shaken, though the foam soon disappears when at rest. It has a peculiar odor, varying in intensity, being most pronounced in concentrated urine. If it has become alkaline, it acquires a disagreeable ammoniacal odor. After ingestion of certain articles of diet, such as asparagus, and after taking different medicines, such as oil of turpentine, cubebs, or copaiba, it emits a more or less characteristic odor.

The constituents of normal urine are partly organic and partly inorganic. The organic constituents, held in solution, are numerous, though many of them are present in extremely small amounts, and are unimportant; the more important are urea, uric acid, oxalic acid, hippuric acid, creatinine, lactic acid, coloring matters, and a minute amount of grape sugar. The coloring matters which may exist in normal urine, though all are not necessarily found in every case, are urobilin, uroxanthin, uroerythrin, and uroindican. The inorganic constituents are chloride of sodium, phosphate of soda, phosphates of magnesia and lime, sulphates of alkalies, and ammoniacal salts. The gaseous constituents are carbonic acid, nitrogen, and oxygen, the latter in very small amount only. The total amount of solids voided with the urine in twenty-four hours is between 60 and 70 grammes, or 925 and 1,080 grains; the organic elements being present in the proportion of 25 to 30 in 1,000 parts, and the inorganic in the proportion of 10 to 15 in 1,000 parts.

Changes upon standing.—If normal urine is left at rest for a few hours, a cloudy sediment, more or less pronounced, will be formed, and is usually more marked in the urine of females. This sediment will disappear entirely upon shaking. It consists of mucus, with a few flat epithelia from the bladder, and, in the urine of females, from the vagina. In addition to these features, epidermal scales from the prepuce and nymphæ will always be found, and at the time of menstruation a large number of blood-corpuscles. Spermatozoa may also be present.

After the urine has remained standing for one or more days, bacteria will develop, their number and rapidity of development

(a) [Red] amorphous red pigment, acid, f. in ur. in Rheumatism, Thro'
(b) yellow Br. f. Uroerythrin = p. in of ur. + in fever etc.
" = Chief " " bile f. in ur. in jaundice etc.

depending upon the temperature. In warm weather they may appear in the course of a few hours. In highly acid urine conidia and mycelia will not infrequently form, though cocci and bacilli may also be found. In alkaline urine fission-fungi, —both cocci and bacilli,—are seen in large numbers. When ammoniacal decomposition of the urine sets in, the urea is gradually transformed into carbonate of ammonium through the activity of the micro-organisms. Saccharomycetæ, or yeast-fungi, may also be present in the urine, and are most common in that containing sugar.

Under pathological conditions the urine may be passed as a cloudy liquid of varying consistency. The highest degree of viscidity is usually found in chronic cystitis, when the urine, being strongly alkaline and decomposing in the bladder, appears as a viscid, stringy, muco-purulent mass, with a repulsive ammoniacal odor; it contains a varying number of bacteria and a large amount of phosphates.

The color of the urine will be greatly changed by an increase or decrease of the normal coloring matters, or the abnormal presence of biliary matter. When the urine is mixed with blood it will be more or less dark colored. In febrile conditions it is, as a rule, highly acid in reaction, and has a reddish or reddish brown color, partly due to an excessive amount of urea and the urates, and partly to a red extractive matter known as uroerythrin. The same may be the case in many slight disturbances of the system.

The amount of urine is usually, though not invariably, increased in diabetes, and its specific gravity is generally high—1.030, 1.040, or more. In some cases of diabetes, however, the specific gravity may not only be normal, but below normal—1.015, or even 1.010—and still a large amount of sugar may be present. The quantity of urine is also considerably increased in cirrhosis of the kidney, but here the solid constituents, and with them the specific gravity, are greatly decreased. Patients suffering with cirrhosis constantly void large quantities of pale, almost colorless urine, nearly destitute of salts, with a specific gravity frequently below 1.010. The amount of urine is decreased in acute inflammations of the kidney, as well as in acute inflammatory conditions of the other organs. Any intense bodily strain, accompanied by free perspiration, will lessen the amount and increase the specific gravity.

Determination of Specific Gravity.—The simplest method of testing the specific gravity is by means of the urinometer, which, if carefully constructed, will be sufficiently accurate for all practical purposes. If tested with plain water, such a urinometer will sink to the 1.000 mark at the average temperature of the room. The specific gravity of a specimen should only be taken after it is cooled; otherwise errors will result. The glass cylinder supplied with the instrument should be fluted, so that the latter will not cling to the side of the glass. The test is made as follows: Fill the cylinder four-fifths full of urine, removing the froth, if any is present, with filtering paper. Place the urinometer in the urine, being careful not to allow it to come in contact with the walls of the vessel. Bring the eye on a level with the surface of the urine, and read the corresponding division of the urinometer, but not the upper rim of the fluid, raised a little by capillary attraction. Touch the stem, causing the urinometer to sink slightly in the fluid, and, after it has come to rest, read again.

If the amount of urine is small, dilute the specimen with one, two, or even three volumes of water; test as before directed, and multiply the number of the division-mark by the number of volumes used in the process of dilution. For example, if two volumes of water have been added to one volume of urine, thus making three volumes in all, and the urinometer stands at 1.006, the real specific gravity of the original urine is 1.018. The solid materials upon which the specific gravity depends, which were dissolved in one volume, are, after dilution, dissolved in three volumes, and the specific gravity is therefore only one-third of the original.

Determination of Solids.—If we wish to determine the amount of solids present in the urine voided during twenty-four hours, we must know the exact quantity passed during this time, as well as its specific gravity. The approximate amount of the solids can be obtained by multiplying the last two figures of the specific gravity by the coefficient of ~~Haeser~~, which is 2.33, and 2 1/3 it will give the number of ~~grammes~~ of solid matter in ~~1,000 cubic~~ centimeters of urine.

For example, suppose we have 1,500 cubic centimeters passed in twenty-four hours, of a specific gravity of 1.020. To estimate the amount of solids in 1,000 cubic centimeters, or 32 ounces, we multiply the last two figures, 20, by the coefficient, 2.33, which

gives us the product, 46.60, the amount of solids, in grammes, in 1,000 cubic centimeters; this is equal to 720 grains. The quantity present being 1,500 cubic centimeters, or 48 ounces, the amount of the solids will be 69.90 grammes, or 1,080 grains. Valuable conclusions as to the amount of solids may thus be obtained from the specific gravity in a very short time. In diabetes, for instance, the quantity of urine voided being large and of a high specific gravity, the amount of solids is considerably increased; in inflammations of the kidney, on the other hand, where the quantity of urine is decreased and the specific gravity is low, the amount of solids is diminished. Since urea composes nearly one-half of the solid constituents, it can easily be seen that in the latter case it has not been excreted in sufficient quantity.

Chapter II

NORMAL CONSTITUENTS

Urea.—Urea is the chief organic constituent of urine, and its most important nitrogenous product. The greater portion of nitrogen taken into the system with the food is excreted by the kidney in the form of urea. The quantity excreted varies greatly under different physiological conditions, but averages between 25 and 40 grammes, or 375 and 600 grains, in twenty-four hours, it being about one-half of the solid ingredients voided. The specific gravity of the urine alone will, therefore, give an approximate idea of the amount of urea therein, provided no sugar is present and the amount of chlorides is normal. A specimen of normal urine with a specific gravity of about 1.020, and voided in a quantity of about fifty ounces, will contain approximately two or two and one-half per cent of urea.

Normally the amount of urea excreted varies greatly with the diet, being most abundant after eating nitrogenous food. It is also increased after muscular exercise and mental activity. Pathologically, it is increased during fevers and in diabetes, in the latter condition sometimes to an enormous extent. It is decreased in diseases of the liver—the liver being the chief seat of the formation of urea,—in diseases of the kidney, and in chronic affections impairing the vitality of the patient.

Urea is always held in solution, and can never be found under the microscope without chemical means. It crystallizes in the form of colorless quadrilateral plates, or prisms, and in needles of varying sizes. It can easily be detected as nitrate of urea by placing a few drops of urine upon a glass slide, adding a drop of nitric acid, warming the slide carefully, and placing it aside to crystallize. Under the microscope, more or less regular rhombic or hexagonal plates, either single or overlapping each other, will now be found. These plates have a little color, and are perfectly characteristic. (See Fig. 1.)

Quantitative tests.—The quantitative tests for determining the exact amount of urea present in the urine are numerous, but more or less complicated. The simplest is the hypobromite method, the principle of which depends upon the fact that, when

FIG. 1. CRYSTALS OF UREA AND NITRATE OF UREA (× 200).

measure

urea in solution comes in contact with a sodium-hypobromite solution, nitrogen is set free as a result of the total decomposition of the urea. The quickest way of carrying out this method is by means of Doremus' ureometer. The hypobromite solution necessary for this test does not keep well, and it is, therefore, best to keep the bromine and the caustic sodium solution sep-

arate. Have on hand a solution of sodium hydrate—100 grammes of caustic soda to 250 cubic centimeters of water (3 ounces to 8)—and the bromine in separate bottles. To prepare the solution, take ten parts of the sodium hydrate solution and one part of bromine, and dilute with equal parts of water; the solution is then ready for use.

Doremus' apparatus consists of a bulb and graduated tube, and a small curved nipple-pipette to hold one cubic centimeter of urine. The bulb of the ureometer is filled with the hypobromite solution, and by inclining the tube, the long arm is filled to the bend at the bulb. By means of the nipple-pipette one cubic centimeter of urine is drawn up, the pipette passed through the bulb of the ureometer as far as it will go in the bend, and the nipple compressed gently and steadily. The urine will rise through the hypobromite and the urea instantly decomposes, giving off nitrogen gas. The decomposition of urea is complete in ten or fifteen minutes, and the graduation on the tube will indicate the quantity of urea in one cubic centimeter of urine. To obtain the percentage, multiply the number of divisions on the tube by 100.

Uric Acid.— Of the other normal organic constituents in the urine, the most important are uric acid and the urates. Uric acid is normally voided in small amount only, and is in direct proportion to the urea, being about 1 to 45; the average quantity voided in twenty-four hours is from 7 to 12 grains (0.4 to 0.8 grammes). Fr. nucleins (distinct alb. of C. nuclei)

The simplest method of determining the presence of this acid is by microscopical examination. Occasionally, however, it may become necessary to employ a chemical test for its recognition, and the quickest is the *murexide test*. A small portion of the sediment, or the residue after evaporation, is placed on a porcelain dish, a few drops of a strong solution of nitric acid are added, and the solution carefully warmed. When dry, a few drops of liquor ammoniæ are added, and a beautiful purple color will at once appear, which soon spreads over the dish, and will change into violet upon the addition of caustic potash.

For the remaining organic constituents, which, so long as they are held in solution, have no practical significance, chemical tests are not necessary. Oxalic acid never occurs in the urine in a free state, but always in combination with lime, and, as such, is seen under the microscope. Creatinine and hippuric acid will

always be found under the microscope when present in abnormally large amounts. Coloring matters, found in small quantities in normal urine, are increased in pathological conditions, and will be considered later on.

The chief inorganic constituents of the urine are the chlorides, sulphates, and phosphates.

Chlorides.—The chlorides present in the urine are chloride of sodium (the most abundant) and small quantities of chloride of potassium and ammonium. The amount of the chlorides voided varies considerably with the diet, being most abundant when a large amount of salty food is ingested. The average quantity voided is between 10 and 16 grammes (2½ to 4 drachms) in twenty-four hours. The excretion of chlorides is diminished in all febrile conditions, especially when attended by serous exudations. In pneumonia they are greatly decreased, and may be entirely absent in severe cases; they may also be diminished in cases of chronic nephritis. (Pleurisy, ascitis, edema.

The chlorides may be detected by treating the urine with nitric acid and adding a solution of nitrate of silver; a cheesy precipitate, soluble by the addition of ammonium, shows the presence of chlorides. A test of the approximate amount of chlorides present may be made with this method as follows: To a small amount of urine in a test-tube add a few drops of nitric acid, and to this one or two drops of a nitrate of silver solution, one part to eight. If a white, flaky precipitate is formed, which quickly sinks to the bottom of the test-tube without diffusing through the urine, the chlorides are present in normal amount (from one-half to one per cent). If a simple cloudiness appears, readily diffusing through the urine without the appearance of flakes, the chlorides are diminished to one-tenth per cent; and if no precipitate whatever is formed, they are entirely absent.

Sulphates.—The sulphates occurring in the urine are mostly those of sodium and potassium, the former predominating. The quantity excreted by the kidneys varies from 2 to 3 grammes (30 to 45 grains) in twenty-four hours. An increased excretion takes place after a meat diet and as a result of active exercise; this is also the case in acute fevers with an increased excretion of urea. Sulphates are diminished after a vegetable diet.

They may be detected by adding to a given quantity of urine in a test-tube one-third as much of an acidulated solution of

barium chloride (2 parts to 8 of water, with one-half part of hydrochloric acid). An opaque, milky cloudiness will appear when the amount of the sulphates is normal. If the opacity is intense, and the mixture has the appearance of cream, the sulphates are increased; but if there is only a slight cloudiness, they are diminished.

Phosphates.—The phosphates present in the urine consist partly of earthy and partly of alkaline phosphates. The earthy phosphates are insoluble in water, and are held in solution in acid urine, but are precipitated in alkaline urine. The alkaline phosphates are soluble in water, and are not precipitated from solution by alkalies. The earthy phosphates are phosphates of calcium and magnesium, and the amount excreted in the urine is from 1 to 1½ grammes (15 to 23 grains) in twenty-four hours. If the acid-magnesium phosphate be acted upon by ammonium, the ammonio-magnesium phosphate—so-called triple phosphate—is formed. The alkaline phosphates are the acid phosphate of sodium and phosphate of potassium; their amount varies from 2 to 3 grammes (30 to 45 grains) in twenty-four hours.

The phosphates vary considerably in amount with the diet, being more abundant after taking vegetables and alkaline waters. The earthy phosphates are increased in diseases of the bone, as osteomalacia and rhachitis, and diseases of the nerve-centers, but are diminished in pronounced diseases of the kidneys.

The earthy phosphates may be detected by rendering the urine strongly alkaline with caustic potash and gently heating, which causes them to precipitate. To detect the alkaline phosphates, remove the earthy phosphates by precipitation, and add to a given quantity of urine one-third the quantity of magnesian fluid (1 part each of magnesium sulphate and ammonium chloride, 8 parts of water, and 1 part of pure liquor ammoniae). All the phosphates are precipitated in the form of a snow-white deposit. If the entire fluid presents a milk-like, cloudy appearance, the alkaline phosphates are present in normal amount; if it is denser and more cream-like, there is an increase, but if the fluid is only slightly cloudy, the phosphates are diminished.

CHAPTER III

ALBUMINOUS SUBSTANCES

Albumin.—Of all the chemical tests, one of the most important is undoubtedly that for albumin, by which term serum-albumin is always meant. The presence of albumin does not necessarily signify the presence of a renal trouble, and, if found in small amount only, may be due to a variety of causes. Even a comparatively large amount may exist without any kidney-lesion whatever, and it is a grave mistake to conclude that a nephritis must exist because albumin has been found. It is undoubtedly true that in the larger number of cases in which albumin is present a nephritis exists, yet in such cases a microscopical examination must always be made, and then only if pus-corpuscles and kidney-epithelia, with or without casts, are found can a diagnosis of a nephritis be made.

On the other hand, a nephritis may exist and yet albumin be found in such minute quantities as to occasionally escape detection altogether. This is sometimes the case in cirrhosis of the kidney, where a large amount of albumin is rarely seen, and it may be entirely absent for a few hours. In such cases the urine of the entire twenty-four hours should be tested before concluding as to the presence of albumin.

In all cases where pus-corpuscles in moderate numbers are found in the urine, albumin will always be detected, if careful tests are made, though there may be no more than a faint trace. It can thus easily be seen that in such widely different lesions as pyelitis, cystitis, prostatitis, urethritis, and vaginitis, it might be present in the urine, and a microscopical examination will be necessary to determine its origin. In hæmorrhage from any portion of the genito-urinary tract, a considerable amount of albumin is usually found. The rare cases of chylous urine, in which the kidney may be perfectly intact, are always associated with the presence of a large amount of albumin.

Disturbances of circulation, due to a variety of different

causes, may bring about the presence of albumin without any structural changes in the kidney or any pus-corpuscles in the urine. Such cases are often roughly termed *functional albuminurias*. It is not always easy to trace the cause of such albuminurias, though they may be due to nothing but prolonged muscular exercise, to lesions of the nervous system, or to organic heart-lesions, etc. If long continued, these cases will sooner or later cause inflammations of the kidney. Albuminuria of pregnancy, due to the pressure of the pregnant uterus, is very common, and in many of these cases an organic lesion of the kidney will develop.

Changes in the composition of the blood with a broken down constitution, as seen in anæmia, tuberculosis, malaria, leucæmia, pyæmia, etc., will cause the appearance of albumin, and this may also be the case in any other febrile condition.

Detection of Albumin in Urine.—1. ACETIC ACID TEST.—The tests for albumin are quite numerous, but one of the most reliable is the following: Fill an ordinary test-tube about one-fourth or one-third full of urine, and boil thoroughly; then add two or three drops of a solution composed of equal parts of glacial acetic acid and water. If albumin is present, the urine becomes cloudy, the cloudiness being the more pronounced the larger the amount of albumin.

The unboiled urine, as brought for examination, is either transparent or cloudy. When the urine is boiled, the results may be the following:

a. The urine is transparent, and upon boiling, remains unchanged. This indicates *normal urine*.

b. The urine is transparent, but after boiling becomes cloudy. By adding a few drops of acetic acid, it clears up entirely. This shows the presence of an increased amount of *phosphates*. If effervescence occurs upon the addition of the acid, either carbonate of lime or carbonate of ammonium (the latter being always held in solution, and never precipitated so as to be found under the microscope) is present.

c. The urine is transparent, but after boiling becomes cloudy, and the cloudiness remains or becomes more pronounced upon the addition of the acid. This indicates the presence of *albumin*, which, in larger quantities, will be thrown down in flakes; when very abundant, the urine may be converted into a jelly-like mass. The acetic acid test will show the presence of the

smallest traces of albumin, though these may escape detection if not carefully observed. The best plan in such cases is to take a second test-tube and pour into it unboiled urine; then compare the two test-tubes in strong light. When this is done, the faintest trace of albumin can be detected by the slight cloudiness in the test-tube containing the boiled urine.

d. The urine is cloudy, but upon boiling clears up entirely and remains clear upon the addition of the acid. This indicates an excess of *urates*, especially urate of sodium.

e. The urine is cloudy, the cloudiness becoming more pronounced upon boiling and the addition of the acid. This shows an excess of *urates, in addition to the presence of albumin.*

f. The urine is cloudy, and remains unchanged by boiling and by the addition of acetic acid. This proves the presence of *micro-organisms*, such as micrococci and bacilli.

2. Nitric Acid Test.—A common test for albumin is the nitric acid test, the urine being boiled, and a few drops of nitric acid added. This test is not as reliable as the preceding, since if a small amount only of albumin be present and the acid added be in excess, the albumin may become redissolved. On the other hand, if the amount of acid added is small and the phosphates are present in excess, a part only of the basic phosphates will be acidified and a soluble albuminate will be formed, which remains in solution.

3. Ferrocyanide of Potassium Test.—Another good test is the following: Fill a test-tube with clear urine, filtering it first if not clear; add 5 to 10 drops of acetic acid and a few drops of a 10 per cent ferrocyanide of potassium solution. If albumin is present, a cloudiness will at once appear, and become more pronounced upon shaking. without boiling.

4. Heller's Test.—Still another frequently employed test is Heller's. It is used as follows: Upon a quantity of pure nitric acid in a small test-tube allow an equal amount of clear urine to trickle from a pipette down the side of the inclined tube, so that the urine overlies the acid. If albumin is present, a sharp white zone will appear at the point of contact between the acid and the urine, varying in thickness according to the amount of albumin present. If only a trace of albumin be present, fifteen to thirty minutes may elapse before the zone becomes visible.

Although a large number of other tests are occasionally used,

these few will be all that are necessary for practical purposes. Perhaps the most reliable is the first one given—the heat and acetic acid test. If doubt remains as to the presence of albumin, any of the other tests given will clear up the question.

Quantitative Test for Albumin.—It is of the utmost importance to have an approximate idea of the quantity of albumin present in any given case, and too many errors are constantly made in this respect. It is by no means rare to hear of a urine containing 25, 40, or even 50 per cent of albumin. What is thereby meant is, of course, per volume; yet such statements are absolutely misleading. As a matter of fact, one-tenth of 1 per cent is a moderate amount of albumin, one-twenty-fifth of 1 per cent being a small amount; one-half of 1 per cent is a large amount, and it is only in comparatively rare cases that 1 per cent or more is present; more than 3 or 4 per cent is probably never found.

The simplest method of estimating the approximate amount of albumin is by means of Esbach's albuminometer. This instrument consists of a graduated glass tube, which is filled with urine to the letter U marked upon the tube, and with the test-solution to the letter R. The latter consists of one part of picric acid to coagulate the albumin, two parts of citric acid to hold the phosphates in solution, and distilled water to make one hundred parts. The tube is now closed with the rubber stopper supplied with it, and the contents thoroughly mixed. It is then set aside for twenty-four hours to allow the precipitate to settle thoroughly, and the amount of the precipitate carefully noted. The tube contains seven main lines of division, each one of which signifies one gramme of albumin in 1,000 grammes,—that is, one-tenth of one per cent. It will be seen that the instrument is only graduated for seven-tenths of 1 per cent, and this is sufficient for most cases. In those rare cases in which more than that amount of albumin is present, the urine must be diluted with one, two, or even three parts of water before testing. It must always be borne in mind that this method can never be absolutely accurate, since picric acid will also precipitate urates, peptone, and vegetable alkaloids; but it undoubtedly gives an approximate idea, which is all that is required in most cases.

Besides serum-albumin, the urine sometimes contains a number of similar but less important substances, among which may be mentioned peptone, globulin, albumose, mucin, and fibrin.

Peptone.—Peptone is never present in normal urine, but is frequently seen in many different conditions in which there is a formation of pus and disintegration of pus-corpuscles somewhere in the body. It has been found in the following conditions: Croupous pneumonia, pulmonary tuberculosis, gangrene of the lungs, empyema, cancer (especially of the gastro-intestinal tract and the liver), different abscesses, acute yellow atrophy of the liver, phosphorus poisoning, typhoid fever, typhus fever, variola, scarlet fever, erysipelas, acute arthritis, etc. It has, however, also been found in physiological conditions, such as the involution of the pregnant uterus, so that its presence does not necessarily signify a diseased condition.

Peptone is easily soluble in water, does not coagulate by heating, and does not precipitate by the addition of most of the reagents used for the detection of albumin, such as nitric acid, acetic acid, and ferrocyanide of potassium.

It may be detected by the following method: To urine which has been slightly acidified by acetic acid, add a solution of sulphate of ammonium to saturation, and filter out any precipitate having formed, which may consist of albumin, globulin, or albumose. If potassio-mercuric iodide or picric acid is now added, and a precipitate occurs, this will be peptone.

Globulin.—Globulin is almost always associated with serum-albumin, and its clinical significance is nearly identical with the latter. It can be detected by the method of Pohl in the following manner: Render the urine slightly alkaline by the addition of ammonium hydrate, and filter after standing one or two hours; then add an equal volume of a saturated solution of ammonium sulphate. If globulin is present, a precipitate forms.

Albumose.—Albumose is an intermediate product in the conversion of albumin into peptone. It has been found in the urine in a number of different conditions, such as osteomalacia, ulcerations of the intestines, and multiple sarcomata. Its clinical significance is not yet positively known. It is not precipitated by heat, but if the urine be made strongly acid with acetic acid, and a concentrated solution of table salt be added, it becomes precipitated. If the cloudy fluid be now heated, it becomes transparent, but turbid again upon cooling, and if more table salt be added, it remains precipitated in spite of heating.

Mucin.—Mucin is present in small amount in every normal urine, being more abundant in the urine of females. It is con-

siderably increased in quantity in catarrhal inflammations of the genito-urinary organs, more especially those of the bladder, the prostate gland, and the urethra. When present in large amount, the urine will appear cloudy soon after it is voided, and it may form a ropy, jelly-like mass, which sinks to the bottom of the vessel. To detect its presence in urine, dilute with equal parts of water and add an excess of acetic acid. If mucin is present, a more or less pronounced precipitate forms. To detect it in urine containing albumin, precipitate the albumin by boiling, and test again with acetic acid. Even small amounts can be detected with the microscope.

Fibrin.—Fibrin is found in the urine in greater or less amount in hæmaturias, due to various causes, and is also seen in chylous urine. In tumors of the bladder, such as papilloma and cancer, where hæmorrhages often take place, it is of frequent occurrence. It is usually present in the form of coagula when the urine is voided, or may be precipitated upon standing. Fibrin is insoluble in water and in salt solutions, as well as in weak acids and alkalies. The latter cause it to become gelatinous upon cooling, becoming soluble again after prolonged boiling. The solutions give the general reactions of albumin. It is, however, much easier to detect its presence by the microscope.

Chapter IV

GRAPE-SUGAR

There can be little doubt that the urine may contain small amounts of sugar under normal conditions, but the amount present in such a physiological glycosuria is so minute that a positive reaction will never be obtained with the general methods of detecting grape-sugar (dextrose).

Pathological glycosuria may appear in the urine as a temporary condition in the course of a number of diseases, such as Asiatic cholera, intermittent fever, cerebro-spinal meningitis, diseases of the heart, lungs, liver, and brain, especially those involving the fourth ventricle, and in gout. It may, furthermore, be present in poisoning with certain substances, such as morphine and carbonic oxide.

Whenever sugar is persistently present in appreciable quantity, we always have to deal with diabetes mellitus. If a large amount of straw-yellow colored urine of a high specific gravity is voided, suspicion must at once be directed toward this disease, and the urine tested for sugar, even if no other symptoms of the affection are as yet present.

Detection of Sugar in Urine.—The tests for sugar are numerous, and in mild cases it may be necessary to resort to two or even three different tests before we are positively able to determine the presence of sugar.

1. Moore-Heller Test.—Perhaps the simplest is the Moore-Heller test. Although by no means absolutely reliable, it is in many cases sufficient to determine the approximate amount of sugar. The method is the following: Pour into a test-tube two parts of urine and one part of a 10 per cent caustic potash solution; boil the upper portion for two or three minutes. Phosphates, if precipitated in large amount, must be filtered off. When sugar is present, a change of color will take place after boiling, which can be approximately estimated as follows: One per cent or less of sugar gives a canary-yellow

color, the color being somewhat more intense than that of the original unmixed urine; between 1 and 2 per cent gives a wine-yellow color; between 2 and 3 per cent a sherry color; between 3 and 4 per cent a rum color, and above 4 per cent a dark brown or even black color. By the addition of a few drops of nitric acid, the liquid loses its dark color, and gives out an odor similar to molasses.

This test is only a tolerably reliable one, but in many cases will answer the purpose. The addition of caustic potash to cold urine may produce a dark color, which is due to the presence of coloring matters of the bile. The white flocculent precipitate, which is almost invariably seen with this test, is partly due to the phosphates which caustic potash may precipitate in cold urine, and partly to mucine.

2. TROMMER'S TEST.—To four parts of urine in a test-tube add one part of caustic potash or soda, adding, drop by drop, a 10 per cent solution of sulphate of copper, and shake until the mixture shows a blue color. Heat the upper part of the mixture, and if sugar is present a precipitate of yellow cuprous hydroxide will result, which at first shows plainly in the bluish liquid, but gradually spreads over the entire fluid, and a red sediment of cuprous oxide is formed.

If this reaction takes place upon heating, a similar mixture may be made and set aside for a number of hours without heating; if sugar is present in rather large quantities, a similar precipitate will form. Should the reaction by heating be at all doubtful, the second test must always be made, since many of the other organic substances, which reduce the salts of copper, do so only after heating and boiling.

This test is open to a number of objections. Albumin, if present in large quantities, must first be removed, since it interferes with the reduction of the cupric oxide. A number of substances are, furthermore, found in urine which have the property of reducing oxide of copper in an alkaline solution, among which may be mentioned uric acid, creatinine, hippuric acid, and mucine. Again, a small amount of sugar may be present in urine, and fail to reduce the oxide in the presence of other substances, such as urate of ammonium, chloride of ammonium, and other ammoniacal compounds.

3. FEHLING'S SOLUTION.—This solution is prepared in the following manner: First dissolve 34.639 grammes of pure

crystallized sulphate of copper in a sufficient quantity of water under gentle heat, and dilute with water to 500 cubic centimeters. Next dissolve 173 grammes of chemically pure crystallized neutral sodium tartrate and 100 cubic centimeters of caustic soda solution, of a specific gravity of 1.12, in sufficient water to make 500 cubic centimeters. It is best to keep these two solutions separate, and mix equal volumes before using. Ten cubic centimeters of this solution will be reduced by 0.05 grammes of sugar.

The solution may be used by pouring a small quantity into a test-tube and diluting it with two or three times the amount of water. The mixture should be boiled for a few seconds. If it remains clear after boiling, which will usually be the case when the two solutions are kept separate and are not too old, add the urine to be tested drop by drop, at the same time continuing the boiling. If sugar be present in any quantity, the first few drops will usually cause a yellow precipitate; if the addition of urine is continued, a yellowish red sediment will soon fall to the bottom of the test-tube. Should no such precipitate occur, the addition of urine may be continued until an equal volume of urine has been added; if then no yellow precipitate appears upon boiling, the urine is free from sugar.

4. Haines' Test.—Take 30 grains of pure sulphate of copper and one-half ounce of distilled water; make a perfect solution, and add one-half ounce of pure glycerin; mix thoroughly, then add five ounces of liquor potassæ. The solution keeps indefinitely if well prepared.

In testing with this solution, pour about one drachm into a test-tube and boil it gently. Next add 6 to 8 drops of the urine and again boil. If sugar be present, a copious yellow or yellowish red precipitate is formed. If no such precipitate appears, no sugar is present.

5. Böttger's Test.—Pour one part of urine into a test-tube and add an equal quantity of a concentrated solution of carbonate of soda, or caustic potash, and a small quantity of subnitrate of bismuth. Boil for a short time. If sugar is present, it reduces the bismuth salts to the black suboxide of bismuth, which will be deposited on the sides of the test-tube. If the quantity of sugar is small, the bismuth will assume a grayish color. Albumin, if present in large quantities, must first be eliminated by boiling and filtration.

6. ROBERTS' FERMENTATION TEST.—This is an excellent and simple test, being used as follows: Into each of two bottles, one of 4 ounces, the other of 12 ounces capacity, pour 4 ounces of urine. Add a piece of fresh yeast the size of a walnut to the urine in the larger bottle, which must be closed with a cork nicked for the escape of gas evolved by fermentation. The smaller bottle must be tightly corked, and the two bottles placed side by side in a uniform temperature of 68° to 75° F.—the average temperature of the room. At the end of twenty-four hours, fermentation will be completed. The specific gravity of each specimen must then be carefully taken by means of the urinometer, and any difference of the specific gravity will indicate sugar, the number of degrees of difference indicating the number of grains per fluid ounce. For example, if the specific gravity of the unfermented urine is 1.035, and that of the fermented urine 1.020, the urine contains 15 grains of sugar to the fluid ounce, or 3 per cent. This test, although not absolutely accurate, is sufficiently so for practical purposes.

These six tests represent only a fraction of those in use, but are the more important and more simple. The others, among them the phenylhydrazin test, are more complicated, and offer no advantages over those described.

Quantitative Tests for Sugar.— For the quantitative determination of sugar in the urine, a number of the tests here given afford an approximative idea, as, for instance, the Moore-Heller and the Roberts tests. The former, however, is not very accurate, and is of little value if the amount of sugar is below 1 per cent. Fehling's solution may also be used for this purpose, and pretty accurate results can be obtained with Einhorn's fermentation saccharometer. Whitney's reagent likewise gives good results.

1. FEHLING'S TEST.— The principle upon which Fehling's solution depends lies in the fact that in the reduction of oxide of copper by grape sugar, the blue color disappears by the addition of a definite quantity of the sugar. As before said, ten cubic centimeters of the solution correspond to 0.05 grammes of sugar. The test may be conducted in the following manner: Dilute one cubic centimeter of Fehling's solution with four cubic centimeters of water in a test-tube, and after heating, add one-tenth cubic centimeter of the urine to be examined from a graduated pipette. Heat must be then re-applied, the precipitate

watched, another one-tenth cubic centimeter added, and the heat again applied, until after allowing it to stand for a short time, it is found that all the blue color is removed from the solution. If, in doing this, one cubic centimeter of urine has been added, it contains one-half of 1 per cent of sugar; if more than one cubic centimeter, it contains less than one-half per cent, but more than one-fourth per cent. If two cubic centimeters are used, it contains one-fourth per cent, and if one-half centimeter is used, it contains 1 per cent of sugar. If the proportion of sugar is large, as is usually the case with a high specific gravity, the urine should be diluted five to ten times.

2. WHITNEY'S REAGENT.—This reagent has given good results, and for practical testing, ten minims of urine only are used. The advantages claimed for it are accuracy, stability, simplicity, and reliability. The formula of the standard solution (parts by weight) is:

	Grammes
Ammonii sulphatis (C. P.)	1.2738
Cupri sulphatis (C. P.)	2.5587
Potassii hydroxide (C. P.)	19.1620
Aquæ ammon. (Sp. gr. 8.80)	312.2222
Glycerini (C. P.)	60.
Aquæ (dest.)	q.s.

One cubic centimeter of the reagent is the equivalent of:

	Grammes
Cupro-diammonium sulphate	0.03832
Cupric hydroxide	0.41062
Grape sugar, anhydrous	0.00526

The following table gives the amounts of sugar in analytical testing:

If reduced by—	*It contains to the ounce—*	*Percentage*
1 minim	16. grains or more	3.33
2 minims	8. "	1.67
3 "	5.33 "	1.11
4 "	4. "	0.83
5 "	3.20 "	0.67
6 "	2.67 "	0.56
7 "	2.29 "	0.48
8 "	2. "	0.42
9 "	1.78 "	0.37
10 "	1.60 "	0.33

The method of procedure is the following: Heat one drachm of the reagent in a test-tube to boiling; add the urine slowly,

drop by drop, until the blue color begins to fade, then more slowly, boiling three to five seconds after each drop, until the reagent is perfectly colorless, like water, or until ten drops only are added. On cooling, the reagent resumes the blue color, the change being due to the absorption of oxygen from the atmosphere. When the urine contains a large amount of albumin, the reduction takes place without interference by the albumin present, but leaves the reagent more or less of a yellow tint. A large amount of coloring matter has a similar effect. If the urine contains a considerable amount of sugar, it is best to dilute it from one to ten times, multiplying the amount found in the table by the amount of dilution.

3. EINHORN'S FERMENTATION SACCHAROMETER.—One of the simplest tests, which will be found to answer all purposes, is by means of Einhorn's fermentation saccharometer. The apparatus is put up in the form of a set, consisting of two saccharometers and one graduated test-tube. The method is the following: Take one gramme (about fifteen grains) of fresh commercial compressed yeast, and shake thoroughly in the graduated test-tube with ten cubic centimeters of the urine to be examined. Then pour the mixture into the bulb of the saccharometer. By inclining the apparatus, the mixture will easily flow into the cylinder, thereby forcing out the air. Owing to the atmospheric pressure, the fluid does not flow back, but remains there. Leave the apparatus undisturbed for twenty or twenty-four hours in a room of ordinary temperature.

If the urine contains sugar, the alcoholic fermentation begins in about twenty to thirty minutes. The evolved carbonic acid gas gathers on the top of the cylinder, forcing the fluid back into the bulb. On the following day the upper part of the cylinder will be found filled with carbonic acid gas. The changed level of the fluid in the cylinder shows that the sugar reaction has taken place, and indicates, by the numbers upon the cylinder to which it corresponds, the approximate amount of sugar present. If the urine contains more than 1 per cent of sugar, it must be diluted with water before being tested; urine of a specific gravity of 1.018 to 1.020 may be diluted twice; of 1.021 to 1.028, five times; 1.029 to 1.038, ten times.

In carrying out this test, it is always advisable to take, besides the urine to be tested, a normal specimen, and make the same fermentation test with it. The mixture of the normal

urine with yeast will, on the following day, have only a small bubble on the top of the cylinder. This proves at once the efficacy and purity of the yeast. If, in the suspected urine, there is also a small bubble on the top of the cylinder, no sugar is present; but if there is a much larger gas volume, we are sure that the urine contains sugar.

It may be mentioned that the urine may, in rare cases, contain other saccharine substances, such as lactose, levulose, and inosite, but they are of no practical importance.

Chapter V

OTHER ABNORMAL CONSTITUENTS

Acetone.—Acetone is found in varying amounts in febrile conditions, in diabetes, in some malignant tumors, in cases of starvation, and in psychoses. It is said to be present in minute amount in many normal urines, and is greatly increased by a meat diet.

It may be detected by *Lieben's iodoform test* as modified by Ralfe: Dissolve twenty grains of iodide of potassium in a drachm of liquor potassæ and boil; float the urine upon the surface of the fluid in a test-tube. At the point of contact, a precipitation of phosphate will occur, which, if acetone be present, becomes yellow and studded with yellow points of iodoform.

Another method of detection is by *Legal's test:* Prepare a fresh, strong solution of sodium nitro-prusside by dissolving a few fragments in a little water in a test-tube. To a few cubic centimeters of the urine add enough liquor sodæ or liquor potassæ to secure a distinct alkaline reaction, and to this add a few drops of the nitro-prusside solution, when a red color will at once appear. This color will quickly disappear, but if acetone is present, the addition of a few drops of concentrated acetic acid will produce a purple or violet-red; if no acetone is present, the latter change will not occur.

Diacetic Acid.—In advanced stages of diabetes, diacetic acid is not uncommon, and is usually of grave significance. It may occur in severe fevers, and also in nervous disturbances.

The best test is the one described by v. Jaksch: To fresh urine carefully add a few drops of a moderately strong watery solution of chloride of iron. If a precipitate of phosphates is produced, remove it by filtration, and to the filtrate add more of the chloride of iron solution. If a red color develops, heat a portion of the urine to boiling, acidulate a second portion with sulphuric acid, and extract with ether. If the urine which has been boiled shows little or no change, while the chloride of iron

reaction with the ethereal extract pales after twenty-four to forty-eight hours, and the urine as well as the distillate contains large quantities of acetone, diacetic acid is present.

Coloring Matters.—BILE PIGMENTS.—When biliary coloring matters appear in the urine, the urine always has an abnormal color—dark yellow, brown, or greenish, and a yellow froth or foam is produced by shaking. The coloring matters are bilirubin and biliverdin, and are met with in the urine in jaundice, from whatever cause it arises, as well as in numerous pathological conditions of the liver, with or without jaundice. They may, furthermore, appear as a result of blood-changes, and after hæmorrhage into the tissues.

One of the best methods for detecting bile-pigments in the urine is by *Gmelin's test*, which consists of placing a small quantity of strong nitric acid, containing a little yellow nitrous acid, into a test-tube and gently floating a similar amount of urine upon it. If biliary coloring matters are present, a set of concentric colored rings will appear at the point of union between the acid and the urine; these rings, from above downwards, will be green, blue, violet, red, and yellow, the green being the most predominant, and is indispensable in proving the presence of bile, the others being sometimes more or less indistinct and even entirely absent. A moderate amount of albumin has no influence upon this reaction.

A modification of this test by *Rosenbach* is also good: The urine is filtered through pure white filtering paper, and, after filtration, a drop of the acid is applied to the inside of the filter; around the nitric acid the same concentric rings will be observed.

Another simple test is *Ultzmann's:* To ten cubic centimeters of urine add three or four cubic centimeters of a 25 per cent caustic potash solution and an excess of pure hydrochloric acid. If bile-pigments are present, the mixture assumes a beautiful green color.

COLORING MATTER OF BLOOD—Hæmoglobin, the coloring matter of the blood, may be found in the urine, either enclosed in the red blood-globules, in cases of hæmaturia, or, in rare instances, dissolved in the urine, the affection being called hæmoglobinuria. Hæmaturia is common, and may occur from diseases of any portion of the genito-urinary tract. Hæmoglobinuria, on the other hand, is only found occasionally in severe

infectious diseases, especially yellow fever; in extensive burns, and poisoning by different substances, such as carbolic acid, phosphorus, and naphthol; also, as a disease by itself, called paroxysmal hæmoglobinuria.

The simplest method of detecting hæmoglobin chemically is by *Heller's test:* The earthy phosphates are precipitated from the urine by the addition of caustic potash and heat; as they become precipitated they carry with them the coloring matter, and are therefore not white, but blood-red. Under the microscope the coloring matter can easily be detected, whenever present in any form.

UROBILIN.—Urobilin is present in small amount in every normal urine, but may be abundant in different pathological conditions, especially those in which a rapid destruction of red-blood-corpuscles takes place. The urine will in such cases have an intense reddish brown color, similar to that containing bile-pigments.

It can be detected in the following manner: Render the urine alkaline by the addition of ammonia; filter, and to the filtrate add a few drops of a 10 per cent chloride of zinc solution. If urobilin be present, a green fluorescence will be observed by reflected light.

INDICAN.—Indican is undoubtedly present in minute amount in every normal urine, is increased by a meat diet, is found in intestinal disturbances and in a number of widely different diseases, though its pathological significance is not yet understood. Having frequently been found in persons suffering from malignant tumors in any part of the body, but more especially the liver, it was at one time considered to be characteristic of such tumors; but this is undoubtedly incorrect. In general, it may be said that large amounts of indican in the urine are caused by an increased albuminous putrefaction in the intestines.

Its detection by *Jaffe's method* is the following: Pour into a test-tube a small quantity of urine, and mix with an equal amount of strong hydrochloric acid; add ten or fifteen drops of chloroform and, drop by drop, a moderately strong fresh solution of chloride of lime, shaking after each drop. The chloroform readily dissolves the freshly formed indigo, and a blue color appears, which is more or less pronounced, according to the amount of indican present.

Fatty Matters.—In rare cases a varying amount of fat, rendering the urine more or less turbid, may be found. Such a condition, in which the fat is present either in a state of minute subdivision or in the form of larger oil-drops, is called *Lipuria* when no albumin is present, or *Chyluria*, when a large amount of albumin is found with an abundance of small fat-globules. The microscope will, of course, reveal its presence at once. Chemically, the addition of ether quickly dissolves the fat, and the urine becomes clear.

Part Second

MICROSCOPICAL EXAMINATION

Part Second

MICROSCOPICAL EXAMINATION

Chapter VI

GENERAL CONSIDERATIONS

Whenever urine is to be examined under the microscope, it should be set aside in a well stoppered bottle or conical vessel, preferably in a cool place, for at least six hours, but better twelve. At the end of this time it will be seen that in every urine, even if perfectly normal, a sediment has appeared at the bottom of the bottle, which is to be used for microscopical examination. This sediment, in normal urine, will be in the form of a cloudy deposit, and consists of mucus, flat epithelia from the bladder and vagina, and a varying number of epidermal scales from the genital organs. Spermatozoa may be present in both male and female urine after sexual intercourse, and in the former after nocturnal emission. It may, furthermore, contain a number of different salts, the character of which will greatly depend upon the diet, their number depending upon the degree of concentration of the urine. It will be found that the sediment of normal urine may contain even a large number of salts in the early morning, when the urine is highly concentrated, while these salts may be almost entirely absent at other times.

After standing for some time, every urine undergoes a change, the rapidity of which depends upon the temperature as well as upon the reaction when passed. An acid urine, which will be perfectly clear when passed, may become turbid upon cooling, owing to the presence of a large amount of urates. Micro-organisms, especially of the class of hyphomycetæ, or mould-fungi, and saccharomycetæ, or yeast-fungi, may sooner or later develop, and in a small degree, schizomycetæ, or fission-fungi. A neutral or even slightly alkaline urine may be clear when voided, but will soon become more or less cloudy, the change

depending partly upon the salts, but mostly upon the development of bacteria belonging to the class of fission-fungi. This change takes place quickly in warm weather, and is, as a rule, more pronounced in the urine of females than in that of males, on account of the bacteria, which are normally found in the vagina.

In pathological urine, the sediment will always be more abundant than in normal urine, though in mild cases the difference is not pronounced. In severe cases, however, it may be very abundant, this being due to pus-corpuscles, blood-corpuscles, epithelia, casts, etc., which it contains. Frequently such urine will be cloudy when voided, and when an excessive amount of mucus is present, will be ropy in character.

Use of Centrifuge.—To overcome the necessity of waiting for precipitation to take place, the *centrifuge* has of late years been considerably used and highly recommended. Much has been said for the centrifugal method, and at times it undoubtedly has its advantages; but, as a rule, it is better to adhere to the old method and wait for six hours, the only precautions necessary being to keep the bottle tightly corked and in a cool place.

One of the chief advantages of the centrifuge is that bacteria are thrown down in large numbers, so that the search for them is more successful. This is especially pronounced in cases of tuberculosis, as tubercle bacilli are found more readily in centrifuged than in non-centrifuged urine.

On the other hand, the great force necessary to effect sedimentation will undoubtedly change some of the minute particles to a greater or less degree. In a number of cases, some of the pus-corpuscles have been seen to assume different forms, partly irregular in character and partly commencing to break down, not present in the non-centrifuged urine, though their number is the same in both. The same can be said of the different epithelia and the spermatozoa, which latter have been seen to assume peculiar forms after the use of the centrifuge. The number of casts has never been found to be appreciably different, though here, too, some have undergone changes. Mucus-threads are more abundant and more likely to take on the form of cylindroids, and this has been found to be quite pronounced in healthy urines, in which no pathological features were present, though these cylindroids often resemble hyaline casts to such a degree as to

be easily mistaken for them. Extraneous fibers, such as cotton-fibers, have been seen to break into minute fibrillæ, and to resemble connective-tissue shreds, when the latter are not present.

When care is exercised in microscopical examination, and only the perfectly distinct features are taken into consideration, the centrifuge can be used; but, with the sole exception mentioned, does not present any advantages over the old method.

Mounting of Sediment.—The urine, in an amount of at least four or six ounces, having been allowed to stand at rest for the required time, the upper portion is carefully decanted or used for chemical tests, and a drop of the lower sediment transferred to a slide for microscopical examination. Although a glass pipette can be used for this purpose, it is simpler to pour the sediment into a small dish and use a camel's hair brush to transfer a drop to the slide. Such a brush can be thoroughly cleansed with water after each examination, and is kept clean easier than a pipette. The drop of urine is put into the center of the slide, and a cover-glass slowly dropped upon it, great care being taken not to press the cover down, since even the small amount of force used may be sufficient to change the epithelia or casts.

Use of Antiseptic Substances.—In order to avoid decomposition of the urine as much as possible, when it can not be examined within twelve or twenty-four hours after being passed, large numbers of antiseptic substances, such as salicylic acid, chloroform, thymol, formaldehyde, and bichloride of mercury have been recommended to be added in small amount to the urine; but when not absolutely necessary, it is better to avoid them. Urine kept in a cool place and in a clean bottle can be examined, even thirty-six hours after being voided, without the danger of having to deal with too many putrefactive changes. In all cases, the chemical analysis should be made as soon as possible. The sediment for microscopical examination can be mixed with a little alcohol, if necessary, or still better, chromic acid.

Preservation of Sediment.—If it is desired to preserve a specimen for a variable length of time, the best method is to add from two to five drops of a 5 per cent chromic acid solution to it; the only change that will take place is that the albumin becomes coagulated, appearing, under the microscope, in the form of irregular granular matter, irregularly scattered throughout the field. The chromic acid will preserve all the features

permanently, not even causing any changes in the casts. Permanent microscopical or slide-specimens are made by adding a few drops of chemically pure glycerin to a small amount of the sediment previously treated with chromic acid, until a jelly-like mass is formed, and waiting for a few days until all the superfluous water has evaporated. It is not advisable to add the glycerin to the sediment mixed with chromic acid until the watery constituents of the urine have become evaporated, which will be the case at the end of one or two weeks. If the sediment has become too thick on account of the evaporation, a little more glycerin is added, a drop then mounted upon a slide, a cover-glass placed upon it, and the whole surrounded by asphalt. Specimens preserved in this manner can be kept for many years without change.

Should it be desired to preserve a large amount of the urinary sediment in a bottle, the chromic acid is added as before; but in that case it will be better to add a larger amount of a weaker solution (about 1 or 2 per cent). After a few weeks the upper part of the liquid is poured off, and a small amount of a 40 or 50 per cent solution of alcohol added, to prevent the growth of mildew. Microscopical specimens can be made years afterwards from urine so preserved, by taking a drop of the sediment, mixing it with a drop of glycerin, and mounting upon a slide in the regular manner.

Magnifying Powers.—Great difficulty is frequently encountered in seeing all the features present in a specimen of urine under the microscope, this being in many cases due to the want of a proper magnifying power. For the study of urine, the magnifying power should always be between 400 and 600 diameters, the average being 500. A good one-sixth dry lens (make immaterial), together with a one-inch eye-piece, will be all that is required. An Abbé condensor should not be used, except for the study of bacteria, nor will an immersion lens be always necessary even then. Both tubercle bacilli and gonococci can be seen with a power of 500 diameters, if the specimen is well stained, although a somewhat higher power, 700 to 800, which can be obtained by using a one-eighth dry lens, is undoubtedly superior. Should it be desired to use an immersion lens for the study of bacteria, an Abbé condensor is essential. The custom of trying to find casts with a lower power, 150 to 200 diameters, can not be recommended, since it is impossible to recognize the other fea-

tures present in the case with such a power, and there are many cases of great importance in which no casts are present. In studying a case under the microscope, it will be found of great advantage to keep a record of all the features as they are found, and also to note their comparative numbers. Sketches of the features will still further simplify the study. Too much stress can not be laid upon the fact that, in the study of epithelia, the comparative sizes of corpuscles and epithelia can alone lead to correct diagnoses, so that the advantages of rough sketches can readily be appreciated.

CHAPTER VII

CRYSTALLINE AND AMORPHOUS SEDIMENTS

The crystalline and amorphous or chemical sediments found in urine are mostly the different acids and salts, though a number of other unorganized sediments may also be present.

I. *ACIDS AND SALTS*

The salts which may be found under the microscope are seen partly in acid and partly in alkaline urine, and the sediments are the following:

A. ACID SEDIMENTS

1. Uric Acid
2. Urate of sodium
   (*a*) Amorphous
   (*b*) Crystalline
3. Oxalate of lime

Common.

4. Cystine
5. Creatinine
6. Hippuric Acid
7. Leucine
8. Tyrosine

Rare.

To these we might add (9) sulphate of lime, which, however, is extremely rare.

B. ALKALINE SEDIMENTS

1. Triple phosphates or ammonio-magnesian phosphates
   (*a*) Complete
   (*b*) Incomplete
2. Simple phosphates or phosphate of lime
   (*a*) Amorphous
   (*b*) Star-shaped, or stellate
3. Urate of ammonium

Common.

4. Carbonate of lime.
   (*a*) Amorphous.
   (*b*) Crystalline, in combination with magnesium salts.

Rare.

5. Phosphate of magnesium.—*Very Rare.*

A. ACID SEDIMENTS

1. Uric Acid.—Uric acid is a constant ingredient of the urine, and is frequently seen under the microscope. Its amount is greatly increased after a rich, nitrogenous diet, more especially

Fig. 2. Crystals of Uric Acid, Common Form (× 400).

of meat, and after physical exercise. It is also augmented in acute febrile diseases and in impeded function of the heart, lungs, and kidney. It is diminished in profuse secretion of the urine, and in the more severe cases of nephritis. When present in small quantities, it may be held in solution.

Uric acid varies greatly in shape and size, and is of a yellowish brown or reddish brown color, except when precipitated in very thin plates, when its color is pale yellow, or it may appear almost colorless. It may be divided into three principal varieties:

Brick

FIG. 3. CRYSTALS OF URIC ACID, COMMON FORM (× 400).

(*a*) The common form; (*b*) as seen in over-acid urine; (*c*) gravel from the pelvis of the kidney. When present in larger amount, it becomes precipitated in the form of reddish masses, producing the so-called brick dust-sediment.

The common form of uric acid (see Fig. 2) consists of rhomboidal prisms—lozenge shape. The lozenges may be large

or small, single or multiple, with round or pointed ends, and at times quite irregular. There may be two lozenges together, giving the twin form, or they may be seen either half-edge or edgewise, or they may be in more or less regular barrels. Be-

FIG. 4. CRYSTALS OF URIC ACID, FROM OVER-ACID URINE (×450).

sides these, complicated formations, crosses, and rosettes, are seen (see Fig. 3), the latter being a conglomeration of lozenges, either in front-view or edgewise, and frequently smaller crystals, sometimes quite irregular, are found within the larger ones.

The second form (see Fig. 4), is often seen in over-acid urine, and is usually found with gouty or rheumatic processes, or

with the formation of uric acid concretions in the bladder. These crystals appear in peculiar spear, comb, and brush shapes, or in exaggerated lozenges. The spear shapes are, in many

FIG. 5. URIC ACID GRAVEL (× 500).

cases, very pronounced. In persons in whom the so-called uric acid diathesis exists, these forms are frequently seen.

The third variety of uric acid (see Fig. 5), is the so-called gravel, which originates in the pelvis of the kidney. Here we meet with concretions of varying sizes, irregular plates, masses, and needles, either single, double, or conglomerated in the form of stars. Occasionally dumb-bell forms are also met with. The passage of such gravel, when at all abundant, is almost inva-

riably accompanied by more or less severe pain. When in larger masses, we have the uric acid calculi or stones, which form the largest number of renal stones, being, perhaps, 70 per cent of all calculi passed.

Quite frequently we may have any two, or even all three, of these varieties of uric acid combined, in large numbers, together

FIG. 6. URATE OF SODIUM, AMORPHOUS (× 500).

with a varying amount of urates and oxalate of lime crystals. When these features are present, the diagnosis of *Lithæmia* is justified.

Although in almost all cases there will be no difficulty in recognizing uric acid under the microscope, there may be extremely thin, practically colorless lozenges or irregular plates which might be mistaken for phosphates. In order to ascertain their exact character, a small amount of some alkali, such as caustic potash or soda, may be added while the specimen is examined under the microscope, when the crystals will be seen to dissolve readily. If now a drop or two of acetic acid be added, small characteristic crystals will soon reappear.

URATE OF SODIUM.—Urate of sodium (see Fig. 6), when present in large amounts, forms the so-called clay-water sediment, which renders the urine turbid upon cooling. It may be found alone or in combination with uric acid and urate of

overfeeding. v. Bennet 170, 4, 192, 206, 99
Fat blood 14 c

potassium, from which it can hardly be distinguished. Such a sediment is the so-called *sedimentum lateritium*. Urate of sodium usually consists of groups of light or dark brown, fine, amorphous granules in a moss-like arrangement, which easily adhere to foreign substances as well as to mucus and epithelia. The groups vary greatly in size, and are at times quite large.

This salt is of common occurrence, and will be found in all slight febrile derangements, after mental and physical exertion, in colds, catarrhs of the stomach and intestines, on the first day of menstruation, and in general malaise; and it may also occur in perfectly healthy individuals where the urine is highly concentrated. It is held in solution while the urine is warm, but quickly becomes precipitated upon cooling. It is the effete material of oxidation, the so-called *materia peccans* of old physicians.

no dnt till minutes

In rare cases urate of sodium is crystalline (see Fig. 7), appearing in the form of needle-like clusters or arranged like sheaves of wheat, or of a fan-shape arrangement, pointed toward

Fig. 7. Urate of Sodium, Crystalline (× 500).

the center, and broader toward the periphery. This sediment has been found in various conditions, such as diseases of the stomach and intestines, and in healthy individuals during prolonged physical exertion. The accompanying illustration was taken from a case of dermoid cyst of the kidney, where the crystals occurred in large numbers with uric acid crystals.

Clay water

Red. diet

Urate of sodium frequently undergoes a change a few hours after the urine is voided, the length of time required for the change depending upon the temperature. The granules commence to change into small brown globules, which are either single or grouped in twos; the latter soon coalesce, and form small dumb-bells, which gradually enlarge (see Fig. 8). This is

FIG. 8. URATE OF SODIUM IN TRANSITION TO URATE OF AMMONIUM (× 500).

the first stage of the formation of urate of ammonium, *the urate of ammonium in statu nascenti*, and denotes a commencing transition of the original acid sediment into an alkaline. When the alkaline change is more or less complete, we have the fully formed globules of urate of ammonium.

3. OXALATE OF LIME.—Calcium oxalate, when present in small or moderate amount in the urine, without an increase of specific gravity, has no clinical significance. Oxalic acid, normally present in all urine in small quantities, has a special affinity for calcium, and appears in the urine as oxalate of lime. It is frequently found after eating certain kinds of fruits and vegetables, such as apples, oranges, bananas, certain berries, grapes, tomatoes, rhubarb, asparagus, spinach, and turnips.

It occurs in a variety of forms (see Fig. 9), but it is always colorless, and of a high refraction. The most common forms are those of quadrilateral octahedrons, greatly varying in size, with single or double lines running from one end of the crystal to the other, crossing each other in the center and giving the charac-

teristic so-called letter-envelope shape; when these are seen edgewise the octahedral form is more marked. These regular forms often commence to break down, so that the lines become lost. A number of these crystals may be arranged together,

FIG. 9. OXALATE OF LIME CRYSTALS (× 500).

either in twos, giving the twin form, or in groups of three, four, or more. With these we often see small, more or less regular squares or dot-like irregular formations, the so-called amorphous shapes. A number of small squares may combine together, giving concretions sometimes of large size, which are especially abundant under the microscope when oxalate of lime calculi are present. They are often massed together upon mucus-threads or foreign substances. Besides these, there are rarer forms, con-

sisting of more or less concentrically striated discs or barrel-shapes, and of variously sized dumb-bells. The latter may assume large proportions, and are easily differentiated from the dumb-bell forms of uric acid or urate of ammonium, by their being colorless.

Oxalate of lime crystals can hardly be mistaken for anything else, if it is borne in mind that they are always without color

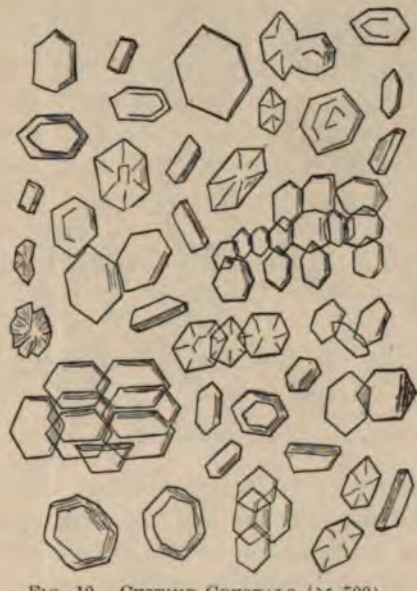


FIG. 10. CYSTINE CRYSTALS (× 500).

and of a high refraction. Although usually present in acid urine only, they may be found in neutral or slightly alkaline urine in small amount. When the reaction of an originally acid urine has become alkaline, they may be transformed into triple phosphates. Should there be any doubt as to their character, they will be found to be insoluble in acetic acid, but soluble in muriatic acid.

When oxalate of lime is present in large amount, with a high specific gravity, 1.028, 1.030, or even 1.040, it often denotes the existence of *Oxaluria*. This affection, although very common, is frequently overlooked. It gives the symptoms of neurasthenia, dyspepsia, melancholia, general malaise, headaches, and ill-defined pains in the lumbar region. Those afflicted are usually of sedentary habits, and are accustomed to live well. In rare cases, especially when concretions of considerable size are present,

hæmaturia, often severe and protracted, is a pronounced symptom. It may last for months, but its cause can at once be ascertained by an examination of the urine. As soon as the

FIG. 11. CREATININE CRYSTALS (× 500).

patient's diet is regulated, and he takes considerable outdoor exercise, the oxalates decrease and the symptoms will improve. With such cases inflammation of the pelvis of the kidney, and sometimes, also, of the kidney proper, though, as a rule, mild in character, is of common occurrence.

4. CYSTINE.— Cystine is a comparatively rare sediment, but may produce concretions in the bladder. It consists (see Fig. 10) of hexagonal, colorless plates of moderate sizes, of high refraction, which, in side-view, present one perfect facet and two imperfect neighboring facets. A number of plates may lie together, one upon another, or they may form more or less regular masses. It is readily soluble in ammonia, one of the features distinguishing it from uric acid, and contains considerable sulphur as a constituent.

Cystine seems to occur in all members of certain families instead of uric acid; in such families it appears to replace uric acid, and in them cystine calculi are not rare.

5. CREATININE.— Creatinine, normally present in the urine in very small amount, is found under the microscope in rare

instances only. It consists (see Fig. 11) of colorless prisms or plates, partly lozenge- and partly barrel-shaped. Frequently there will be two, three, or even more plates, one within the other, or the plates may conglomerate in groups. Occasionally, more particularly when the urine has stood for some time, peculiar configurations will appear in the interior of the plates.

Creatinine is found most frequently after prolonged muscular exercise, as is seen in athletes during active training. A rare sediment, found in the urine of a perfectly healthy athlete, is shown in Fig. 12. This sediment contains plates and lozenges of creatinine, the rare crystalline form of urate of sodium, and peculiar formations, consisting partly of fan-shaped and partly of angular crystals, from which a varying number of long needles are seen to emanate. Some of these crystals resemble rarer forms of urate of ammonium,

Clinically, creatinine has been found in cases of severe acute parenchymatous nephritis, associated with uræmic convulsions,

FIG. 12. SEDIMENT IN THE URINE OF AN ATHLETE (× 500).

and has also been seen in the urine of females suffering from puerperal eclampsia.

6. HIPPURIC ACID.—Hippuric acid, which is present in all normal urine, is almost always held in solution, though it may

be found in small amount after a vegetable diet, and after eating certain fruits, such as cranberries and plums. In the urine of herbivorous animals, especially in horses, it is of common occurrence. It will be found in larger amount after the administration

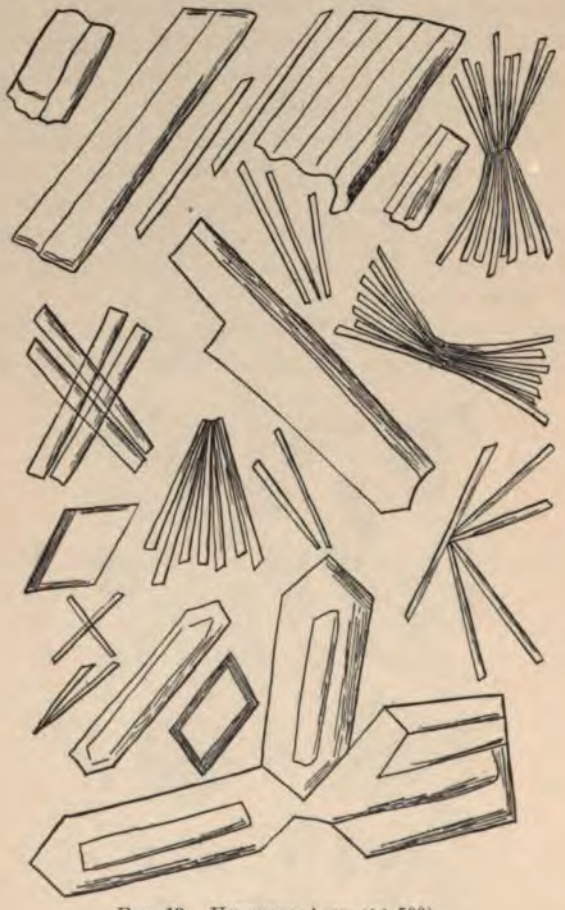


FIG. 13. HIPPURIC ACID (× 500).

of benzoic acid, or one of the benzoates; also, sometimes, in diabetes. " in Kidneys → Hippuric .

It consists (see Fig. 13) of variously sized, colorless prisms and plates, often conglomerated into larger or smaller masses. The plates may be thin and extremely long, at times resembling needles. Hippuric acid might occasionally be mistaken for some

forms of phosphates, but can easily be differentiated from them by its insolubility in acetic acid.

7, 8. LEUCINE AND TYROSINE.—Leucine and tyrosine are rare sediments, and usually occur together. They are never seen in normal urine, but mostly in severe acute and usually fatal

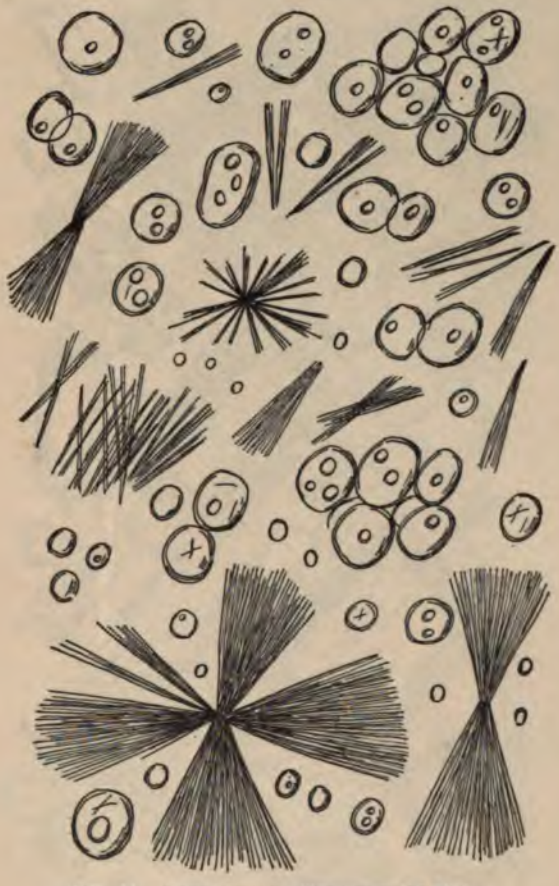


FIG. 14. LEUCINE AND TYROSINE (× 500).

diseases of the liver, such as acute yellow atrophy of the liver, yellow fever, and phosphorus poisoning. They have also been found in cases of small-pox, scarlet fever, and typhoid fever.

Leucine (see Fig. 14) appears under the microscope in the form of flat, yellowish or brown globules of different sizes, with delicate radiating and concentric striations. Tyrosine is found

alk

in the form of needle-shaped crystals, grouped in clusters or sheaves, crossing at various angles.

Both leucine and tyrosine somewhat resemble fat, the former the fat-globules, the latter the needles of fat—so-called margaric acid,—but differ from fat by being insoluble in ether.

h. Veg. diet

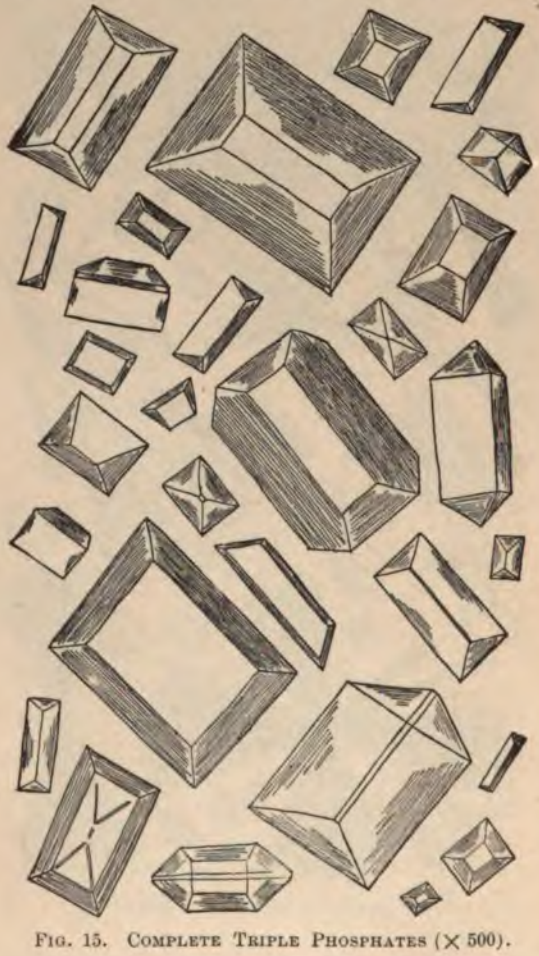


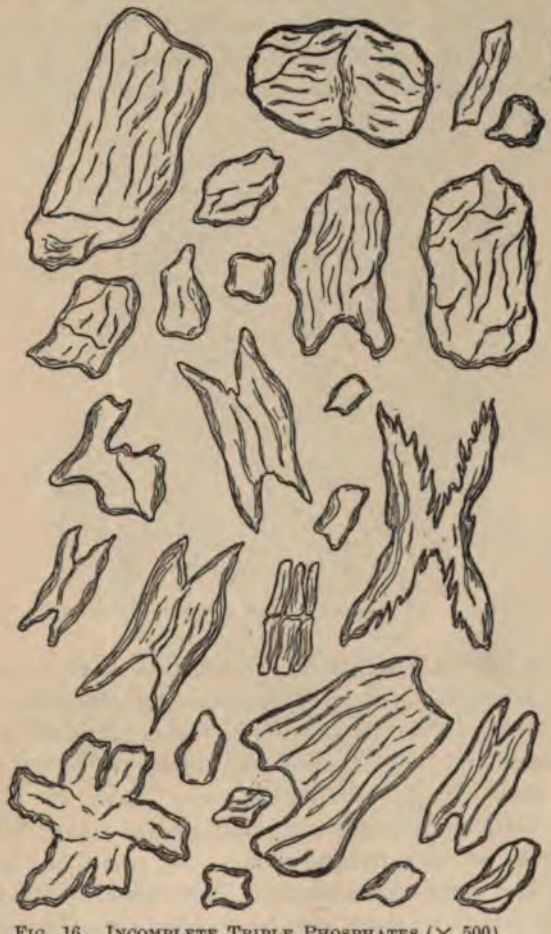
FIG. 15. COMPLETE TRIPLE PHOSPHATES (× 500).

9. SULPHATE OF LIME.—Sulphate of lime has been described as occurring in the urine in an extremely small number of cases. It consists of thin, colorless prisms or needles, either single, in groups, or in rosettes, resembling crystalline phosphate of lime, but more regular. Its clinical significance is not known.

Alk

B. ALKALINE SEDIMENTS

1. TRIPLE PHOSPHATES.—Triple phosphates, the combined ~~ammonio-magnesian~~ phosphates, may be divided into complete and incomplete. They may be found under the microscope in small numbers in urines which still give a slightly acid reaction,



h. Veg. diet
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FIG. 16. INCOMPLETE TRIPLE PHOSPHATES (× 500).

but invariably denote a change to alkalinity. When present in large numbers, the urine is always alkaline. Acid oxalate of lime is frequently seen to undergo a transformation into alkaline phosphates. As all urates are colored to a greater or less degree, all phosphates are invariably colorless.

Complete triple phosphates (see Fig. 15) are colorless, triangular prisms or rhomboidal crystals, highly refractive, with beveled ends,—the so-called coffin-lid shapes. They vary greatly in size and shape, the latter being different when the crystals are seen in front-, side-, or top-view. Some of the smaller ones can hardly be differentiated from oxalate of lime crystals.

Incomplete triple phosphates (see Fig. 16) are seen in many forms and sizes. It seems that these crystals are in part not yet fully developed (especially the smaller varieties, which may in

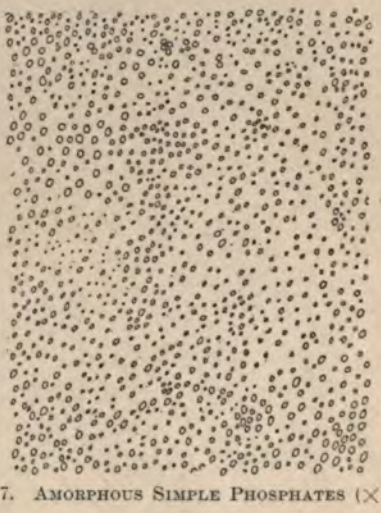

FIG. 17. AMORPHOUS SIMPLE PHOSPHATES (× 500).

time grow and become complete), and in part have become broken down from previously complete forms. All the different transitions can be seen in the same specimen when it is studied on two or three successive days, which can easily be done by simply adding a drop of glycerin to the urine upon the slide. The incomplete forms represent irregular plates, either without any interior marks or with irregular lines, the result of the transformation of the complete crystals. The crystals may be broken down in the center, or there may be peculiar cross-like formations, or even irregular star-shaped crystals, which can be likened to a fern leaf.

Triple phosphates may be found in varying numbers in normal urine after a vegetable diet. Their amount is greatly increased in chronic inflammatory conditions of all kinds, in rheumatic processes, in inflammation of the bones, etc. They are

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especially abundant in cases of chronic cystitis, where an alkaline putrefaction of the urine takes place in the bladder, and may be

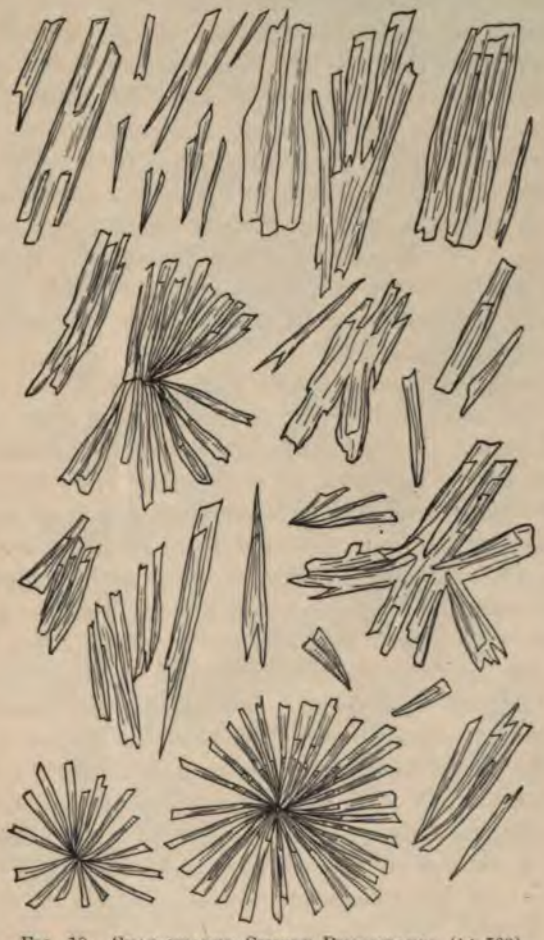

FIG. 18. STAR-SHAPED SIMPLE PHOSPHATES (× 500).

precipitated in large, flaky deposits, the urine having a pronounced ammoniacal odor.

2. SIMPLE PHOSPHATES.—Simple phosphates, or phosphates of lime, are of two distinct varieties: first amorphous, and second star-shaped or stellate.

Amorphous simple phosphates (see Fig. 17) appear in the form of highly refractive, colorless globules or granules, either single or clustered together in variously sized groups, but never

" separate

in a moss-like arrangement, as the urate of sodium. These phosphates are abundantly found after a milk diet, as well as after drinking different alkaline mineral waters.

Star-shaped or stellate simple phosphates, although of less frequent occurrence than the other variety, are by no means rare, and are often found in conjunction with the triple phosphates. They consist (see Fig. 18) either of slender, colorless rods, or of pointed spiculæ of various sizes, at times containing smaller ones in their interior. Although they may be found single, their characteristic grouping is in the form of stars or rosettes, more or less complete. The spiculæ, of which the rosettes are composed, are united in the center of the rosette, while each spicula may have a uniform diameter, or be broadened at the periphery and narrowed in the center.

Much has been written about the significance of the phosphates in the urine, and great stress has been laid upon their continual increase or diminution, the latter being said to be of constant occurrence in cases of nephritis. It is an undeniable fact that the phosphates will be diminished in severe and usually advanced cases of nephritis, but not more so than the other salts, there being a pronounced decrease of all salts in such cases.

In rare cases, there is a continual increase of the phosphates in the urine, without any apparent cause. Such cases have been designated by the term *Phosphaturia*, and they may give similar symptoms to those of oxaluria. The phosphates precipitating in the urine being frequently secondary formations, such a diagnosis must only be made when their amount is found to be greatly increased immediately after the urine is voided, and the presence of inflammatory conditions of any kind in the body can be excluded. A change of diet will often rectify this trouble in a short time. All phosphates are easily soluble in acetic acid, which will quickly clear up any doubt as to their character.

3. Urate of Ammonium.—Urate of ammonium is a common sediment in alkaline urine, especially in connection with triple and simple phosphates, and is seen in fresh urine only when it is passed in an alkaline condition. It is the result of an alkaline change of either urate of sodium or uric acid. It appears (see Fig. 19) in the form of brown globules of various shapes and sizes, usually exhibiting pronounced concentric and radiating striations. The globules may appear singly or in clusters, sometimes forming large, coalesced masses. They are either smooth or

provided with thorny, sometimes branching and curved offshoots, —the so-called thorn-apple shapes. The offshoots vary greatly in size and number, there being either one or many upon a single globule. When uric acid changes to urate of ammonium, the masses are large and irregular, at first showing the lozenge shape of the uric acid, but gradually becoming transformed. Not

FIG. 19. URATE OF AMMONIUM (× 500).

infrequently the globules, especially the smaller ones, will conglomerate so as to form concretions, sometimes of large size, and this may also be the case when mucus-threads or foreign substances, such as cotton- or linen-fibers, are present.

The alkaline change, which may take place in an originally acid urine, is illustrated in Fig. 20. When the urine was voided it contained nothing but a large number of uric acid crystals of different forms, both plates and needles, some groups of urate of sodium, and crystals of oxalate of lime. After about twelve

hours fermentative changes commenced to appear, and fungi, in the form of conidia and mycelia, developed. The urate of sodium granules were now found to have partly changed into small globules and dumb-bells, the first formed urate of ammo-

FIG. 20. ACID SEDIMENT IN FERMENTATION AND IN TRANSITION TO ALKALINE (× 500).

U, uric acid plates; UN, uric acid needles; US, urate of sodium in transition to urate of ammonium; UA, urate of ammonium; O, oxalate of lime; C, conidia; M, mycelia.

nium in *statu nascenti*. This change gradually continued until larger globules of urate of ammonium, as well as more irregular forms, had developed. Triple phosphates had not formed.

4. CARBONATE OF LIME.—Carbonate of lime is a rare alkaline sediment, occurring either alone or in combination with the

alk

phosphates. It is usually found (see Fig. 21) in the form of amorphous granules and globules of small size, though larger than the globules of amorphous simple phosphates, either singly or in groups of varying sizes, and of very high refraction. Occasionally dumb-bell forms are also seen. Besides the amorphous variety, it occurs in combination with magnesium salts, in crystalline shape, as small, delicate prisms, somewhat resembling

cloudy-alk.

fr. ac. fruits. (?) lemo

FIG. 21. CARBONATE OF LIME (× 500).

the small plates of incomplete triple phosphates. By adding an acid, such as acetic acid, effervescence is produced, which also occurs in the presence of ammonium carbonate, though this is always held in solution, and never seen under the microscope. Carbonate of lime is the most common sediment in herbivorous animals, and the turbidity of their urine is due to its presence.

This salt appears mainly in inflammatory and carious processes of the bony system, such as osteitis, osteomyelitis, osteomalacia, and rhachitis. It may also be found in diabetes and phthisis. After drinking certain mineral waters in large quantities it may be seen in the urine.

5. PHOSPHATE OF MAGNESIUM.— Phosphate of magnesium is an extremely rare sediment, producing colorless, highly refractive, elongated, quadrilateral prisms. It is observed in the urine after the internal use of the fixed alkali-carbonates, such as are held in solution in many mineral waters.

II. *OTHER UNORGANIZED SEDIMENTS*

Fat.—Fat, in the form of globules and granules, is of common occurrence in the urine, but care must be taken not to confound it with extraneous fat-globules, which, in many cases, are larger, more irregular, and of a more yellowish color. If fat is not present in too large quantities, the microscopical appearance of the urine is not changed, but if it exists in large amount, as, for instance, in the rare cases of *Chyluria*, in connection with considerable albumin, the urine is turbid or milky when voided, and after standing, a peculiar creamy layer will appear at the top

FIG. 22. FAT-GLOBULES AND MARGARIC ACID NEEDLES (× 500).

of the urine. When fat-globules are voided in such large quantities as to be seen with the naked eye, and albumin is either entirely absent or present in small amount only, the diagnosis *Lipuria* is justified; these cases are, however, just as rare as those of chyluria. The addition of a few drops of ether will clear up the urine to a certain degree.

Fat-globules and -granules vary considerably in size (see Fig. 22). When the larger globules are found, needles of margaric acid may also be present; these are long, slender formations, in which a double contour can be seen only in rare instances. They lie between the globules as well as within them in some cases, and may also appear to emanate directly from them.

Fat-globules have a high refraction, and usually a rather dark contour.

Leaving out of consideration the rare cases of chyluria and pronounced lipuria, the latter of which has been observed in healthy individuals temporarily after a highly fatty diet, as well as in pregnant women and cases of phosphorus poisoning, the appearance of a small or moderate number of small fat-globules and granules, either singly or in variously sized groups, is seen in all cases in which a chronic inflammation, even of mild character, exists somewhere in the genito-urinary tract. These globules are not only found lying free throughout the different fields, but in varying numbers within the epithelia and pus-corpuscles, being undoubtedly a secondary product of the protoplasm. The globules may make their appearance in small numbers a few weeks after the commencement of the inflammation, but will be found in greater quantity only in chronic cases; the more numerous the globules, the more pronounced the inflammation. At first, one or two glistening globules of very small size are seen in the granular protoplasm, which condition becomes more and more pronounced, until the fatty degeneration, in severe cases, attacks the whole of the epithelium, occasionally changing its appearance completely.

Such fat-globules will, therefore, be found not only in chronic cases of nephritis and pyelitis, but also in cystitis, prostatitis, urethritis, and vaginitis. In the different varieties of nephritis, their numbers vary greatly. When present in small or moderate numbers only, no other diagnosis than that of a chronic inflammation is justifiable; but if very abundant, either with or without the presence of fatty casts, a diagnosis of fatty degeneration can be made.

Cholestearin.—Cholestearin, a normal ingredient of bile, is occasionally found in the urine. It consists (see Fig. 23) of colorless, thin, irregular rhomboidal plates, frequently broken in different parts, and of greatly varying sizes. It easily dissolves in ether, and takes on a reddish or violet color if treated with iodine and a drop of a sulphuric acid solution.

Cholestearin has been found in a few cases of chronic cystitis, in rare cases of chronic parenchymatous nephritis with fatty degeneration, and in chyluria. Its exact significance is unknown.

Haematoidin.—Hæmatoidin crystals seem to be the result of

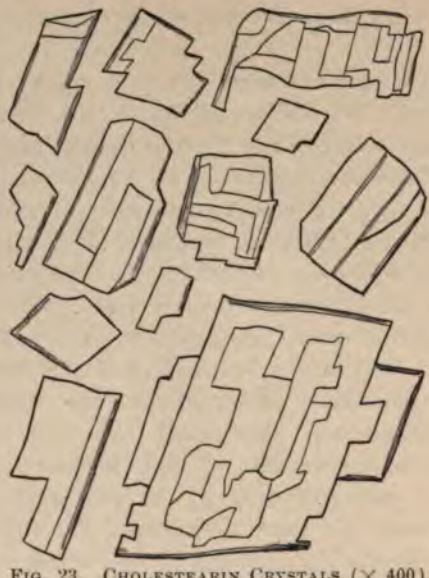

FIG. 23. CHOLESTEARIN CRYSTALS (× 400).

extravasated blood, if retained within the tissues. They appear in the urine (see Fig. 24) in the form of small, irregular plates,

FIG. 24. HÆMATOIDIN CRYSTALS (× 500).

as well as needle-shaped, sometimes stellate, crystals of a reddish brown, or rather rust-brown color. The needle-shaped crystals vary considerably in size, and may be found either singly or in

conglomerations of peculiar forms. Not only may the needles be arranged so as to form bunches resembling the bristles of a brush, but an irregular mass may be surrounded by a large number of needles, sometimes giving a crab-like appearance. The larger formations are rare, while the smaller are comparatively common, not only lying free, but also in the interior of pus-

FIG. 25. INDIGO CRYSTALS (× 500).

corpuscles and epithelia. Their presence always denotes a hæmorrhage, which has taken place at some previous time, and they may, therefore, be found in a variety of different lesions.

Besides hæmatoidin, it is claimed that *bilirubin* may be found under the microscope, closely resembling the crystals of hæmatoidin, and seen in both plate and needle form. They are usually larger and more irregular than the former, and their relationship is still undecided.

Indigo.—All normal urine contains a small amount of indican, and the indigo occasionally found in the urine is, as a rule, a secondary product of oxidation, often seen when putrefactive changes have developed. In rare cases the urine has a bluish color when voided, the indigo having been formed in the body; this is seen in pathological conditions only.

Indigo (see Fig. 25) is seen in the form of blue rhomboidal crystals of small size, or irregular masses, as well as in needles and thin plates. Although it was formerly always considered to have a pathological significance, it is now known to be present in perfectly normal conditions. It is not uncommon to see indigo under the microscope in small amount as extraneous matter from

the underwear, and this can not, in most cases, be distinguished from that formed in the urine.

Melanin.—Another coloring matter which at times is seen in the urine is melanin, appearing as dark brown, or perfectly black, irregular granules or masses of small size. It has been found in melanotic tumors, such as sarcoma and cancer, as well as in broken down constitutions due to various troubles, and can not be said to have any special significance.

URINARY CONCRETIONS

Quite frequently concretions may form in the urinary passages and be found in the urine. When very small, these concretions are called gravel; when large, stones or calculi; the former can be passed in large amount with little or no pain, the latter cause great suffering, and the condition may require surgical interference. Concretions are formed either in the kidney, pelvis, or bladder, and most frequently consist of uric acid, urates, oxalate of lime, or phosphates. Besides these, concretions of cystine and carbonate of lime, as well as indigo and xanthin, may be found.

Concretions may consist of one ingredient only, or of two or more in alternate layers. The majority of concretions have a central portion or nucleus, and a peripheral portion, or body. The nucleus varies in size and composition. It may consist of the same material as the body, though, as a rule, some organic product, such as a blood-clot or mucus-thread, will form the nucleus, around which the body of the calculus forms. In rare cases, foreign bodies introduced into the bladder from outside become the nuclei of stones.

The most common are the uric acid concretions, which may be passed in large amount in the form of gravel, but often attain a large size. They compose from 70 to 80 per cent of all concretions, and are formed either of uric acid alone or combined with the urates; are hard, and have a yellowish brown or reddish brown color. Oxalate of lime concretions have a grayish color, and may be either small, round, and smooth—called hempseed calculi,—or large, rough masses,—the mulberry calculi. Sometimes the nucleus of these concretions consists of uric acid. Phosphatic concretions are usually formed of mixed triple phosphates and phosphate of lime. They are mostly of large size,

and have a grayish white color. Other concretions are of rare occurrence. In many cases their nature can easily be determined by placing a minute particle in a drop of glycerin under the microscope.

Although the presence of concretions, even when very minute, can almost invariably be determined by microscopical examination of the urine, a number of examinations must not infrequently be made before the diagnosis becomes positive. The first urine examined may contain a small number of salts only, or these may be entirely absent under the microscope, though subsequent examinations will show them in large amount, and clear up any doubt. In all such cases inflammations or hæmorrhages from the kidney, pelvis of kidney, or bladder will sooner or later develop.

Chapter VIII

BLOOD-CORPUSCLES AND PUS-CORPUSCLES

I. *BLOOD-CORPUSCLES*

Red blood-corpuscles or -globules are of frequent occurrence in the urine, and may be derived from any portion of the genito-urinary tract. When present in small numbers, the color of the urine will not be changed, but when they occur in large numbers, the urine has a reddish hue, and may be of a dark red color. Although their appearance almost invariably indicates some

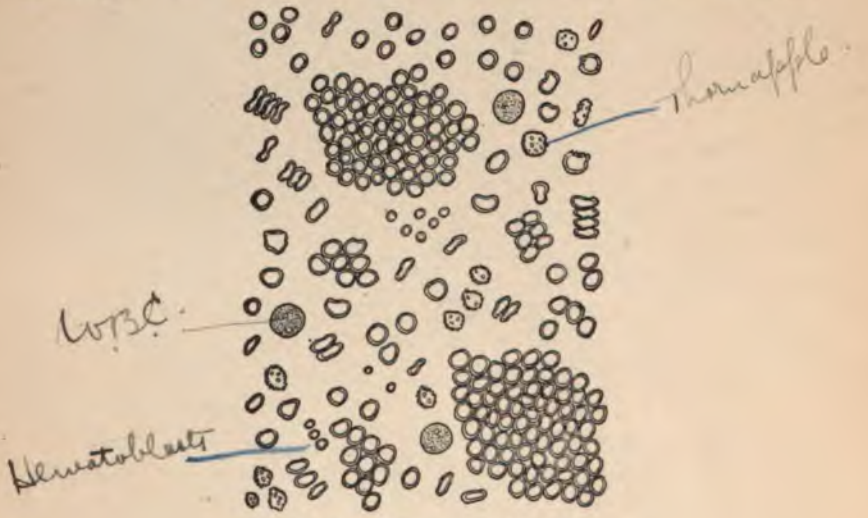

Fig. 26. Blood-Corpuscles (× 500).

abnormal condition, however slight, it must never be forgotten that they are present in female urine at the time of menstruation.

Red blood-corpuscles, as found in the urine, vary considerably in appearance, shape, and size (see Fig. 26). In fresh urine they are discoid bodies of a yellowish hue, and frequently crenated,

but after a few hours only, may have entirely lost their hæmoglobin, and are then practically colorless. This change takes place quickly in alkaline urine, but more slowly in acid urine. When the specific gravity of the urine is low, they are frequently colorless when voided. As long as they contain considerable hæmoglobin, they have a yellowish color; as soon as they commence to lose their coloring matter, a double contour can always be seen, the interior being in most cases apparently structureless. This is the condition in which they are most frequently found.

When they are present in large numbers, they are found both singly and conglomerated in variously sized masses, and the so-called thorn-apple shapes are often seen. When they lie edgewise, they appear biscuit-shaped, and may be found in small masses like rolls of coin; the latter is comparatively rare in urine. As a rule, they are neither granular nor nucleated, and can thus easily be distinguished from pus-corpuscles, even if the double contour is not well marked. In acid urine, however, after it has been standing for a few days, a small number may appear granular.

Urine containing blood-corpuscles invariably contains albumin, and the greater the number of blood-corpuscles the more marked the albumin. In severe cases of hæmaturia, the amount of albumin may reach one-half of 1 per cent or more, and still the kidneys be perfectly normal, the blood coming, perhaps, from the bladder, the urethra, or the prostate gland.

When the urine is of a low specific gravity, the red blood-corpuscles frequently imbibe water, swell up, and become hydropic. In such cases they are large, pale, double-contoured bodies, and are called "ghosts." On the other hand, a varying number of small corpuscles are seen in every hæmorrhage, which are sometimes less than half the size of the regular corpuscles, but perfectly characteristic. These are of recent formation, are in process of growth, and are called hæmatoblasts, a name given to them in 1872 by Carl Heitzmann, and in 1878 by Hayem.

Whenever a large number of red blood-corpuscles is present in the urine, a small number of *white blood-corpuscles* or *leucocytes* is invariably seen. They vary in amount, but average one of the latter to 400 or 500 of the former. Leucocytes can not be distinguished from pus-corpuscles. They are usually found in the form of globular, granular bodies, though they may easily change their form on account of the contractility of their protoplasm.

When a hæmorrhage is present, and these corpuscles are seen in small numbers only, they should not be called pus-corpuscles.

In an active hæmorrhage, we frequently notice, besides blood-corpuscles, *fibrin* as well as *clots of blood* (see Fig. 27).

Fibrin appears either in the form of thin, pale, colorless strings, or larger, more or less reddish or brown masses, fre-

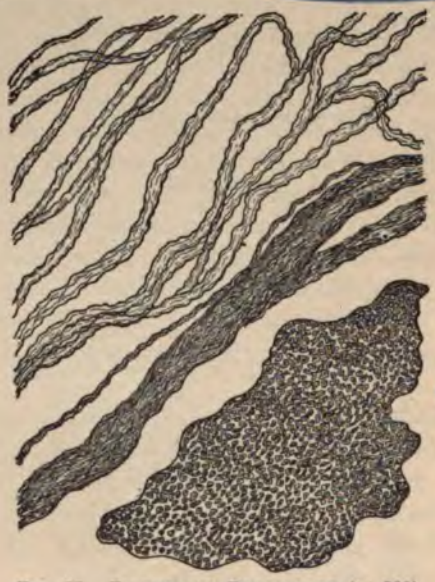

FIG. 27. FIBRIN AND BLOOD-CLOT (× 500).

quently giving off smaller branches. It always consists of wavy bands, having a higher refraction at the periphery than in the center, and having a characteristic appearance. When large, the masses can easily be seen with the naked eye. In rare cases, such as severe hæmorrhages due to tumors or parasites, they may attain enormous size, and not infrequently form regular casts.

Blood-clots consist of irregular, rust-brown or dark masses, varying in size, and composed of disintegrated blood-corpuscles; they may be so dense that their structure cannot be made out, and they must be diagnosed from their color.

When blood-corpuscles, even in small numbers, are present in the urine, it is absolutely essential to discover their source. This can only be determined by the nature of the epithelia in the urine. As long as the hæmorrhage is not too severe, epithelia can

always be found without any difficulty, but in the worst cases of hæmaturia, epithelia may be present in small numbers only, and sometimes many drops of urine must be examined before their source can be positively determined. Even in these cases, however, epithelia will be found. The color, reaction, and specific gravity of the urine, as well as the nature of the hæmaturia, can never afford any positive clue as to the source of the blood.

The pathological conditions in which blood-corpuscles are found are numerous. They are present in small or moderate numbers in every acute inflammation, whether of mild or severe character, and even in plain irritations or hyperæmias. They will be found in a prostatitis as well as in a nephritis, also in pyelitis and cystitis. The presence in the urine of an abnormally large amount of salts may be sufficient to set up an irritation of the kidney or pelvis, with the appearance of blood-corpuscles.

Regular hæmorrhages from the genito-urinary organs are also of comparatively frequent occurrence and due to many causes. Perhaps among the most frequent of these cases are hæmorrhages from the pelvis of the kidney, often due to gravel or calculi. Severe inflammations, abscesses, ulcers, tumors, stricture of the urethra, or traumata of different kinds, as well as parasites, will cause them. A little care exercised in discovering all the features present in the urine will, in most cases, lead to a positive diagnosis of the source of the hæmaturia.

II. *PUS-CORPUSCLES*

Whenever *pus-corpuscles* are present in the urine, even in small numbers, we can be certain of an abnormal condition somewhere in the genito-urinary tract. If they are very scanty, we need not necessarily have an inflammation to deal with, though there is undoubtedly an irritation in some portion of the tract. As soon as they are found in at least moderate numbers the diagnosis of an inflammation can at once be made, which is the more pronounced, the greater the number of pus-corpuscles, and when extremely numerous we may even be justified in diagnosing suppuration, though not without other features.

Urine containing pus-corpuscles in small numbers may appear perfectly normal to the naked eye, but the greater their number the more turbid it becomes, and in urine in which they

are abundant a heavy, cloudy sediment will sink to the bottom in the course of a few hours. In such cases the term *Pyuria* might be properly used. Every urine in which pus-corpuscles are present in any appreciable number will contain albumin, no matter from what organ they are derived, and the larger the number of pus-corpuscles the greater the amount of albumin.

Pus-corpuscles are derived not only from the connective-tissue cells, but also to a great degree from the epithelia themselves, the protoplasm of which becomes changed by endogenous

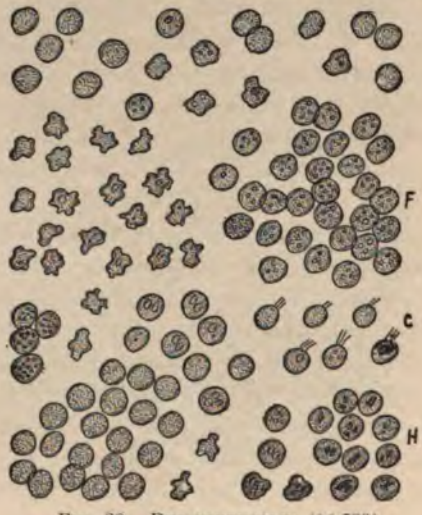

FIG. 28. PUS-CORPUSCLES (× 500).

F, pus-corpuscles with fat-globules; C, ciliated pus-corpuscles; H, pus-corpuscles with hæmatoidin crystals.

new-formation to inflammatory corpuscles, which later reach the surface of the epithelia and are carried along by the urine as pus-corpuscles. They appear mostly as small, round, granular bodies, perhaps twice the size of normal red blood-corpuscles, in which one or more nuclei may or may not be seen; but in freshly passed urine not infrequently exhibit active amœboid changes, assuming a variety of irregular forms (see Fig. 28).

In dilute, as well as in highly alkaline urine, the pus-corpuscles swell and assume a large, globular shape, becoming hydropic. In these a central nucleus will be observed, while the granulations around the peripheral portions become pale or almost entirely disappear. In ammoniacal urines, as seen in chronic cystitis, the pus-corpuscles, when present in large numbers, burst and coalesce,

producing a sticky mass, which can be transferred to the slide only in jelly-like lumps. In such cases, a large amount of mucus is always present, and it may become almost impossible to differentiate the pus-corpuscles from mucus-corpuscles.

The apparent presence or absence of nuclei in the pus-corpuscles depends entirely upon the amount of granulation; in coarsely granular corpuscles they are invisible, but become well marked when the granulation is fine. Not infrequently a varying number of small, glistening fat-globules and -granules will appear in the pus-corpuscles, and this fatty change may be so pronounced that almost the entire granulation appears altered. Such a pronounced change always denotes a chronicity of the inflammation, although the fat-globules may commence to appear a few weeks after the beginning of the inflammation, when the process can not as yet be called strictly chronic. In perfectly acute inflammations, however, they are never found.

Sometimes pus-corpuscles are seen which contain delicate, rust-brown crystals of hæmatoidin, in both needle and plate form. This is more especially the case in those derived from epithelia of the pelves of the kidneys and the uriniferous tubules of the kidneys, and denotes a previous hæmorrhage. In recent hæmorrhages the pus-corpuscles may have a uniform yellow color, due to the imbibition of the coloring matter of the blood. In cases of chronic catarrhal cystitis, dark brown pigment-granules may sometimes be found in the pus-corpuscles. Occasionally pus-corpuscles which have delicate hair-like prolongations—cilia—are seen. These arise from the ciliated columnar epithelia of the uterus, and when present justify the diagnosis of an endometritis. Care must be taken not to mistake bacteria adhering to the surface of the pus-corpuscles for cilia.

Constitution.—Pus-corpuscles, when present in moderate or large numbers, will invariably allow us to form an opinion as to the constitution of the patient. All pus-corpuscles are granular, the nature of this granulation varying with the constitution of the individual. This fact was first announced in 1879 by Carl Heitzmann, and thousands of examinations have proved the correctness of his assertion. It is easy to recognize the different appearances of the pus-corpuscles, not only in different cases, but to a certain degree in the same case, if attention is paid to this fact; some corpuscles appear highly

refractive and coarsely granular, while others are pale and finely granular (see Fig. 29).

Coarsely granular, refractive, nearly homogeneous corpuscles, without any apparent nucleus, show an excellent, first-class constitution, and the more numerous these are in a given case, the better the constitution. The coarse granulation is due to a large amount of living matter; the less living matter present, the finer will be the granulation, and, therefore, the poorer the constitution. In persons having a good constitution, the granulation

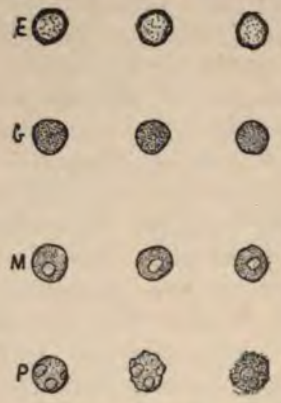

FIG. 29. PUS-CORPUSCLES SHOWING DIFFERENT CONSTITUTIONS (× 500).

E, excellent; G, good; M, medium; P, poor.

is still coarse, though not to such a great degree as in those of an excellent constitution, and the pus-corpuscles will not appear as highly refractive as in the latter. When the granulation becomes less coarse, a nucleus will be seen in the pus-corpuscle. This is proof of a medium constitution, while very finely granular pus-corpuscles, with one or more pale nuclei, indicate a poor or broken down constitution.

If all the different varieties of granulation, from the coarsely granular down to the finely granular, are present, we can come to the conclusion that the patient had originally a good, or even excellent constitution, which has become weakened by disease, and the more abundant the finely granular nucleated bodies are, the greater has been that weakening. A few months or weeks before the death of an individual, if the same occurs from a chronic ailment, or even a very short time before death, if it occurs from an acute affection, the pus-corpuscles break down completely,

and become changed to finely granular, pale, irregular masses. These facts can be verified in every case, and will be found of invaluable aid in the prognosis. A little study, even with no higher power than 500 diameters, is sufficient to easily see the differences here noted.

Attention must, however, be drawn to the fact that it is easy to confound mucus-corpuscles, which are always pale and finely granular, and are present in every normal urine, with pus-corpuscles. Mucus-corpuscles are normal products of the epithelia, vary considerably in size and shape, and are not nucleated; they are, of course, useless in diagnosing the constitution, as are hydropic pus-corpuscles.

Pus-corpuscles may be derived from any portion of the genito-urinary tract, and their source can only be determined by the nature of the epithelia present in the urine. Being invariably found in every inflammation, the mildest as well as the most pronounced, they are among the most common of all the elements found in the urine. To diagnose an inflammation of the kidney, it is by no means necessary to find casts, since a number of kidney-lesions, sometimes quite severe in character, exist without the presence of casts. Irritation from a large number of salts, which is common in the pelvis of the kidney, is sufficient to show a small number of pus-corpuscles. Although highly alkaline urine frequently accompanies an inflammation of the bladder, no positive conclusion can be arrived at without the characteristic epithelia. Again, in the urine of a female, a large number of pus-corpuscles may be present without any other trouble than a vaginitis, though this may be sufficient for considerable amount of albumin to appear. The same may be said of prostatitis and urethritis. Any doubt as to the origin of the pus-corpuscles will at once be dispelled by finding the characteristic epithelia in the urine.

Chapter IX

EPITHELIA

With very few exceptions, epithelia present in the urine always denote a pathological process of some kind. In normal urine the only epithelia to be found are irregular, flat epithelia from the bladder, in small numbers, while in urine of females there may be flat epithelia from the vagina; the presence of all other epithelia is pathological. Although it is claimed to be impossible to diagnose the sources of the different epithelia in the urine, this is not at all difficult, provided a few general points are always borne in mind; and it is only by an accurate knowledge of their sources that we are able to obtain a diagnosis of the location of the morbid process. Most of the morbid processes occurring along the genito-urinary tract are inflammatory in nature, and marked by the presence of pus-corpuscles in the urine, and the location of the inflammation is determined by the epithelia.

Before speaking of the nature of the different epithelia found in the urine, it is necessary to have an idea of the general characters of the epithelia occurring in the body. These are of three kinds: First, *flat* or *squamous;* second, *cuboidal;* and third, *columnar* or *cylindrical.* Flat epithelia are always more or less irregular in outline, exhibiting a broad front surface, while in edge view they are narrower, and somewhat spindle shaped. Cuboidal epithelia have about the same diameter in all directions, while columnar epithelia are elongated in one direction. The latter may be ciliated, having one or more delicate hair-like prolongations on the outer surface. All epithelia are granular, and possess one or more nuclei, which, however, need not always be visible, and may have dropped out, leaving a vacuole. The granulation may be coarse or fine, the flat epithelia being frequently more finely granular and paler than the others.

All epithelia may occur either in a single layer or stratified; that is, there may be a number of different layers. Wherever

stratified epithelia occur, and all three varieties are present, the flat variety is seen to compose the outer or upper layers, the cuboidal the middle layers, and the columnar the inner or deepest layer, nearest to the connective tissue.

In the genito-urinary tract, a lining of stratified epithelium is found in the pelves of the kidneys, the ureters, bladder, urethra, vagina, and cervical portion of the uterus, while a simple epithelial lining exists in the uriniferous tubules of the kidneys, the prostate gland, ejaculatory ducts, Bartholinian gland, and mucosa of the uterus.

It is maintained that the epithelia from different organs, such as the bladder, ureters, and pelves of the kidneys, are identical in size and shape. By scraping off the epithelia of these organs, this idea appears correct, but if the epithelia are examined in situ, we will soon be convinced that their size varies considerably. The largest epithelia are found in the vagina; the next in size in the bladder; then, in order, those of the cervix uteri, urethra, pelves of kidneys, ureters, and prostate gland; the smallest in the uriniferous tubules. It must not be forgotten, however, that there are transitional sizes, which are of no value for diagnosis. The smallest cuboidal epithelia from the bladder, for instance, may be identical with the largest cuboidal epithelia from the pelves of the kidneys, but the average size is absolutely different, being considerably smaller in the pelves than in the bladder. Again, the caudate and lenticular forms of epithelia are far more prevalent in the pelves and calices than in the bladder, and are well adapted for a diagnosis.

All epithelia will change to a certain degree in the urine, more especially the cuboidal, which are originally angular polyhedral formations; by the imbibition of the watery constituents of the urine they swell and assume a more or less regular, even perfectly spherical, form. This change will affect all epithelia alike, and the size of the spheres is sufficient for a diagnosis of their previous location.

In the vagina and bladder, where the epithelia are large, the difference between the flat, cuboidal, and columnar varieties is naturally most marked, while in the pelves, ureters, urethra, and cervical portions of the uterus it is not so pronounced. In the prostate gland the simple epithelial lining is cuboidal, while in the duct of the prostate gland it is columnar. In the ejaculatory ducts, as well as in the mucosa of the uterus, ciliated

columnar epithelia are present, though in the urine the cilia break off easily, and may not be seen. In the uriniferous tubules of the kidney the simple epithelial lining varies in different portions, being partly flat, partly cuboidal, and partly columnar; the flat and cuboidal epithelia can not be distinguished, while the columnar variety is well marked.

In every urine, flat, horny epithelia from the genitals,—the prepuce in the male, and the clitoris and labia in the female—are frequently found, and are called epidermal scales (see Fig. 30). They have a jagged contour and a rather high refraction, and do

FIG. 30. EPIDERMAL SCALES (× 500).

not contain a nucleus, but are frequently studded with dirt-particles and fat-globules. In addition, their granulation—if any is present at all, which is rarely the case—is extremely pale, and they appear more or less shriveled. They vary in size and shape considerably, and must not be mistaken for epithelia or crystals of incomplete triple phosphates, which latter they sometimes resemble.

In attempting to diagnose the sources of the different epithelia, it must be remembered that nothing but size will positively differentiate them, and that a small number of epithelia may be found,

the source of which can not be told positively; the larger number, however, are absolutely characteristic.

The epithelia found in the urine may be divided into: first, those common to both sexes; second, those found only in the male; and third, those found only in the female.

Epithelia Common to Both Sexes.—The epithelia found in both sexes are those from the bladder, the pelves of the kidneys, the ureters, and the uriniferous tubules of the kidneys. The urethral epithelia are also the same in both sexes, but are most common in the male.

Epithelia from the Bladder (see Fig. 31).—The epithelia from the bladder are of three distinct varieties, and are easily recognizable; these are flat epithelia from the upper layers, cuboidal from the middle layers, and columnar from the deepest layer. Flat epithelia may be seen both in front view and edgewise, when they may appear more or less folded. A small number of these epithelia, without the presence of pus-corpuscles, may be seen in every normal urine. They have no significance whatever, since the flat epithelia continually desquamate in health, though in a small amount only. As soon as they occur with pus-corpuscles and with cuboidal epithelia, they have a pathological significance. These flat epithelia may be seen either singly or in clusters of varying size. Although the size of these epithelia is distinctly smaller than that of the epithelia from the upper layers of the vagina, a small number may occasionally be found, of almost the same size as the latter, coming from the neck of the bladder, near the prostate gland. Their number, together with the size of the cuboidal epithelia, and the fact of their not containing bacteria, will be sufficient to clear up the diagnosis. p238

Cuboidal epithelia from the middle layers are never found in normal urine; they may be scanty or numerous. When cuboidal epithelia are present in moderate or large numbers, with many flat epithelia from the upper layers, the diagnosis of an acute process can be made. If, on the other hand, the upper layers are scanty or entirely absent, the process is a chronic one. Whenever fresh recurrences of an old process set in, the flat epithelia will become more numerous.

Columnar epithelia from the deepest layer of the bladder are found only in the severer processes, such as intense inflammation, ulceration, hæmorrhage, and tumors. Care must be taken not to mistake the folded upper layers for these more coarsely granular

and highly refractive epithelia—those from the upper layers being paler and more finely granular.

Mention should here be made of an occurrence, which, though it may be found in the epithelia of any organ, is most pronounced

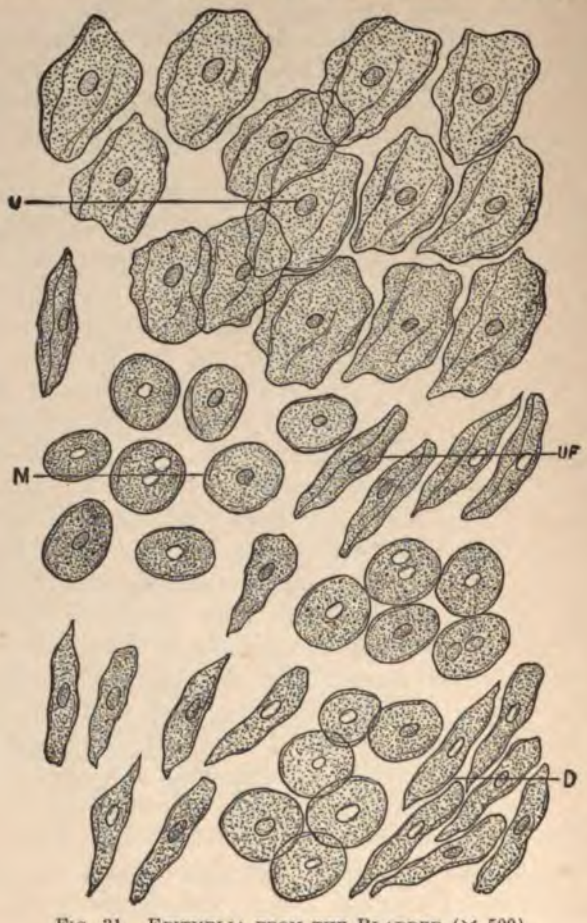

FIG. 31. EPITHELIA FROM THE BLADDER (× 500).

U, upper layers; UF, upper layers, folded; M, middle layers; D, deepest layer.

in the larger cuboidal epithelia of the bladder. In different epithelia from the middle layers, a number of nuclei or even newly formed, so-called endogenous, pus-corpuscles will be found. Their number varies from two to four, five, or even more. That pus-corpuscles are formed within epithelia can be easily observed. A few of these new-formations can often be seen in different

inflammations, but larger numbers will be found in the epithelia only after a long-continued irritation through some pressure, usually from the outside. Such endogenous new-formations will be seen in cases of hypertrophied prostate gland, undoubtedly caused by pressure of that organ upon the bladder, as well as in different exudations behind the bladder, such as a parametritic exudate, or a tumor in the wall or vicinity of the bladder.

All cuboidal and columnar epithelia may contain a varying number of secondarily developed, glistening fat-granules and

FIG. 32. EPITHELIA FROM PELVIS OF KIDNEY AND URETER (× 450).

-globules similar to those seen in the pus-corpuscles. This is invariably an indication that the process has lasted for some time, and is not an acute one. A large number of these globules always indicates a chronic process.

Epithelia from Pelvis of Kidney (see Fig. 32).—In the pelves of the kidneys the epithelia also vary considerably in shape, being partly globular, but mostly irregular. They are smaller than those from the bladder, but larger than those from the ureters, the epithelia from which latter are almost always present with those from the pelves. The majority of the pelvic epithelia are caudate, pear-shaped, or lenticular, though they are sometimes quite irregular; the regular, cuboidal shapes, smaller than those from the bladder, being less numerous. The epi-

thelia are frequently seen with uric acid gravel, which causes an irritation or inflammation of the pelvis.

Epithelia from the Ureters.—Epithelia from the ureters are rarely found alone, but usually with those from the pelvis. Their characteristic shape in the urine is round or globular; being distinctly smaller than those from the pelvis. They can not be differentiated from the epithelia of the prostate gland, which they closely resemble. Their number in the urine is, as a

FIG. 33. EPITHELIA FROM URINIFEROUS TUBULES OF KIDNEYS (× 500).

C, convoluted tubules ; S, straight collecting tubules.

rule, small; and the fact of their being associated with epithelia from the kidney and pelvis of kidney makes their diagnosis easy.

Epithelia from the Uriniferous Tubules of Kidneys (see Fig. 33).—Epithelia from the uriniferous tubules are the most important of all the epithelia found in the urine, and those most frequently overlooked. Whenever they are present in the urine, with pus-corpuscles, even when no casts whatever can be found, the diagnosis of a nephritis is certain, since they are never seen in normal urine. Two distinct forms are found: the cuboidal from the convoluted tubules, and the columnar from the straight collecting tubules. These epithelia are distinctly smaller than either those from the pelvis of the kidney or the ureter in the

same case, though their sizes vary to a certain degree in different cases.

In every case examined, the first step is to look for pus-corpuscles, which are known to be small in some individuals and comparatively large in others, and are usually the smallest granular corpuscles seen. As soon as these are decided upon, the next step is to determine whether bodies distinctly larger than these are present. If such bodies, one-third larger than pus-corpuscles, are found in at least moderate numbers, we can be certain that they are epithelia from the convoluted and narrow tubules of the kidney. The presence or absence of a nucleus has no significance whatever, although such a nucleus is usually found in the kidney-epithelia, but may be invisible in the pus-corpuscles. The relation between the size of the pus-corpuscles and that of the epithelia from the convoluted tubules is always the same; that

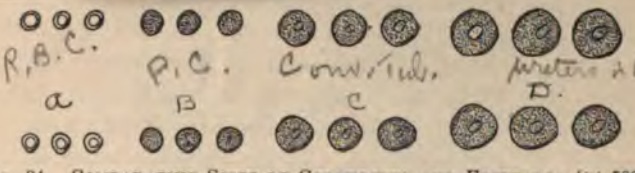

FIG. 34. COMPARATIVE SIZES OF CORPUSCLES AND EPITHELIA (× 500).

is, the latter are one-third larger than the former. If the pus-corpuscles happen to be small in the case examined, the kidney epithelia will be small; but if large, the epithelia will be large.

The comparative sizes of the different smaller formations found in the urine are illustrated in Fig. 34. The smallest corpuscles with double contour, and which are not granular, are the red blood-corpuscles; the next in size, being the smallest granular corpuscles, are the pus-corpuscles; then follow the smallest epithelia found in urine, one-third larger than the pus-corpuscles—the epithelia from the convoluted tubules of the kidney. Finally, the next larger epithelia are shown, always twice the size of the pus-corpuscles, which are either those from the ureters or the prostate gland, between which no difference can be noticed. If this relationship is kept in mind, no mistake can be made, though it must be remembered that when an individual small epithelium is found, the diagnosis can not be made positively until compared with the pus-corpuscles.

Besides the cuboidal epithelia, columnar epithelia from the straight collecting tubules are sometimes found. The latter are, as

a rule, not as abundant as the former, and are almost invariably seen in larger numbers in the severer cases of nephritis only. Their size, as compared with that of the cuboidal epithelia, is about the same, they being narrower, but elongated. In very acute cases of nephritis, clusters of kidney epithelia, as well as cast-like tubes of epithelia, though not necessarily regular casts, may be found.

Although it is the usual custom to rely entirely upon the presence of casts in the urine before making the diagnosis of a nephritis, it will be found that casts are frequently absent, even in pronounced cases of kidney inflammations, as, for instance, in catarrhal or interstitial nephritis; and that even in cirrhosis of the kidney, casts are, as a rule, entirely absent, or if present, are extremely scanty. If care is taken to look for epithelia one-third larger than pus-corpuscles, the diagnosis of a nephritis can be made in many cases which are otherwise overlooked, even though a small or even moderate amount of albumin be present in the urine. Too much stress can not be laid upon this fact, as, in many cases where the clinical symptoms undoubtedly point to a nephritis, the diagnosis is abandoned, because no casts are found. This variety of nephritis is much more common than is usually supposed, though in most cases of a milder character than the parenchymatous variety, and it may often last for a number of years without being detected.

Epithelia Found in Urine of Male.—The epithelia found in the urine of the male are those from the urethra, the prostate gland and its duct, and the ejaculatory duct (see Fig. 35).

Epithelia from Urethra.—The epithelia from the urethra vary considerably in shape and size, being partly flat, partly cuboidal, and partly columnar, and are all comparatively large and irregular, so that they can be easily diagnosed in almost all cases. The larger irregular, partly flat, partly cuboidal epithelia are seen in milder inflammations, such as the first stages of catarrhal or gonorrhœal inflammations; the irregular columnar or cylindrical epithelia occur only in deeply seated inflammations or ulcerations, which often lead to the formation of a stricture.

Epithelia from Prostate Gland.—The epithelia from the prostate gland are partly cuboidal and partly columnar, the latter always originating in the duct of the gland. The cuboidal epithelia are of exactly the same size as the cuboidal epithelia from the ureters, being twice as large as the pus-corpuscles in every case, and distinctly larger than those from the convoluted tubules

of the kidney. When epithelia of this size are seen in a given case, care must be observed to take the relative numbers of these, as well as of those from the convoluted tubules and the pelvis of the kidney, into consideration before reaching a posi-

FIG. 35. EPITHELIA FROM URETHRA, PROSTATE GLAND, AND EJACULATORY DUCTS (× 500).

UE, urethra; PE, prostate gland and its duct; EE, ejaculatory duct.

tive diagnosis. For instance, if they are present in large numbers, while those from the kidneys and pelves are entirely absent or seen in small numbers only, they are undoubtedly prostatic. The clinical history, if known, will, of course, clear up this point still further.

The columnar epithelia from the duct of the gland, which are distinctly larger than those from the straight collecting tubules of the kidney, are rarely absent in pathological processes of the prostate gland, and will render the diagnosis plain, since columnar epithelia from the ureters, which they resemble, are not frequently seen, and, when present, are usually found in small numbers only.

Mention should also be made here of the fact that in rarer cases pale, concentric formations of varying sizes are found with the prostatic epithelia. These are the so-called prostatic concretions, colloid or amyloid corpuscles of the prostate gland (see

Fig. 36). They are irregular, partly oval, partly angular bodies, which have a high refraction and a more or less pronounced concentric striation, frequently with an irregular central nucleus. Their number seems to be augmented in some cases of hypertrophy of the gland.

Epithelia from Ejaculatory Ducts.—Epithelia from the ejaculatory ducts may also be found in the urine. They are of the

FIG. 36. SPERMA AS FOUND IN URINE (× 500).

columnar ciliated variety, and perfectly characteristic. The cilia are not always seen, since they break off easily and become lost; but delicate parallel rods in the interior of the epithelia, near their basal surface, may then indicate that the epithelia were originally ciliated. When no cilia or rods are found, their size alone will usually be sufficient for a diagnosis, as they are smaller and considerably narrower than those from the bladder.

Sperma.—Not infrequently sperma, the characteristic ingredients of which are the spermatozoa, is found in urine, normal as well as pathological. This will be the case after sexual intercourse, as well as after emissions, and in spermatorrhœa, which latter can best be diagnosed from the almost constant presence of sperma in urine, especially the first urine voided in the morning. When sperma is found in small amount only, the appearance of the urine is not changed; but when present in large amount,

cloudy, flaky deposits are seen, which, when examined, prove to be sperma.

In urine, the positive diagnosis of sperma can only be made when spermatozoa are found, though prostatic epithelia, and occasionally spermatic concretions, may be present (see Fig. 36). The other ingredients of sperma, such as the sperma-crystals, will not be seen in urine.

Spermatozoa, which are about $\frac{1}{500}$ or $\frac{1}{600}$ of an inch long, consist of a flattened, oval, or pear-shaped head, a small cylindrical middle portion or neck, which, however, is not always seen, and a long, wavy, tapering tail, considerably broader at the head than at the end. In perfectly fresh urine a slight motion of the spermatozoa may be visible for a short time, but disappears very soon. They are extremely resistent toward chemical reagents, and may be found well preserved in urine after days, even when it is strongly alkaline.

The number of spermatozoa in urine varies greatly. Under normal conditions the spermatozoa are rarely abundant, while in cases of spermatorrhœa they are usually quite numerous, and may be present in very large numbers. In cases of spermatocystitis or seminal vesiculitis they are frequently seen, and many of them will be found changed, the head gradually enlarging, becoming more round and often granular. It is not unusual for the head to assume the size of a pus-corpuscle, which it may resemble to such a degree that it is impossible to differentiate it from the latter; in appearance, it is like a pus-corpuscle with a tail. In these cases regular pus-corpuscles, epithelia from the prostate gland, and frequently, also, from the ejaculatory ducts, will be present.

Urethral and Gleet-Threads.—Although no distinction should be made between urethral and gleet-threads (the latter originating in the urethra), there are cases in which men who have never suffered from gonorrhœa will void small, transparent mucus-threads with the first morning urine. These are always scanty, and consist of nothing but mucus, both fibers and corpuscles, together with the larger, flat, superficial urethral epithelia. These masses are conglomerations of mucus in the urethra, and are not pathological.

On the other hand, we find in the urine of persons who have suffered from gonorrhœa, at one time or another, either only a short time previously or many years before, a varying number of

threads which differ in size, and may appear either perfectly transparent or more or less opaque. These are the regular gleet-threads (see Fig. 37).

It is not uncommon to find such threads accidentally in the urine of persons who, though they suffered from gonorrhœa a long time previously, have not noticed any symptoms for years. In these cases they are, of course, small and scanty. More

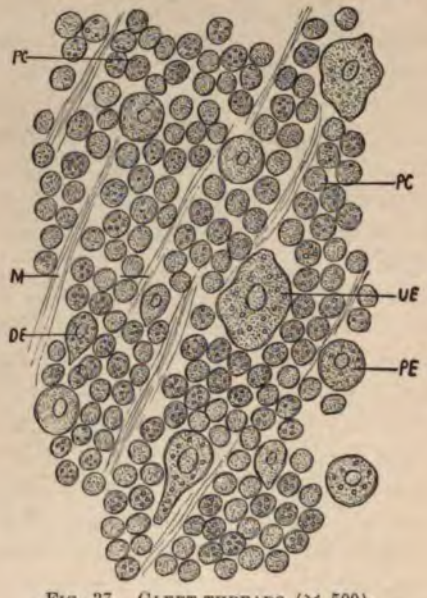

FIG. 37. GLEET-THREADS (× 500).

PC, pus-corpuscles ; M, mucus-fibers ; PE, epithelium from the prostate gland ; DE, epithelium from the duct of the prostate gland ; UE, epithelium from the urethra.

frequently are they found in those cases of chronic gonorrhœa in which slight symptoms, such as a moisture at the orifice of the urethra, or an adhesion of the lips of the meatus in the morning, with subsequent discharge of a minute drop of either mucous or muco-purulent fluid, are present. The number of threads in cases of this kind is at times very large. Fortunately, gonococci are not found in all these cases, but may be entirely absent in the larger number, and repeated careful examinations will fail to find them.

Regular gleet-threads consist of mucus, pus-corpuscles (the latter usually abundant in the more pronounced cases), and a varying number of epithelia from the urethra and the prostate gland; sometimes, also, from the neck of the bladder. The

larger number of pus-corpuscles, as well as most of the epithelia, will be found studded with fat-globules and -granules, which latter are not infrequently seen in smaller or larger groups upon and between the mucus, outside of the pus-corpuscles and epithelia. The more chronic the case, the more numerous will be the fat-globules. The appearance of such so-called gleet-threads under the microscope is always perfectly characteristic, though the name is misleading, since, when they are large, a number of fields will be found crowded with pus-corpuscles, mucus, and epithelia not in the least resembling a thread.

The more severe the case, the more abundant will be the pus-corpuscles, and care is necessary in such cases not to make an error in the diagnosis, which would be easy when the presence of gleet-threads is not suspected. A wrong diagnosis of an abscess might thus be made, although such a diagnosis is never justified without the presence of a number of connective-tissue shreds, which are never seen here. In the milder forms the mucus is abundant, and the pus-corpuscles mixed with it often change and assume various irregular shapes, the spindle shape being frequent. It is impossible to judge of the chronicity of a case from these, as has been claimed. Again, the pus-corpuscles may swell up and become hydropic, or the cover-glass may have been accidentally pressed in mounting the specimen, either of which is sufficient to change the appearance of the pus-corpuscles. Spermatozoa may at times be found mixed with the gleet-threads, but will, of course, not affect the diagnosis in any form.

Epithelia Found in Urine of Female.—The epithelia found in the urine of the female are those from the vagina, the Bartholinian gland, the cervix of the uterus, and the mucosa of the uterus.

Epithelia from Vagina.—The epithelia from the vagina are the largest found in the urine; those from the upper layers are flat, those from the middle layers are cuboidal, and those from the deepest layer are columnar (see Fig. 38).

The flat epithelia are present in varying numbers in most female urines, and, when found alone have no significance, since they continually desquamate in health. When leucorrhœa is present, as is almost always the case, in a small degree, in healthy women who have borne children, their number is considerably augmented. They may be found singly or in variously

Look dense like a stick studded w. cells.

sized clusters, and are always large, irregular, and usually studded with bacteria,—both cocci and bacilli. They frequently contain large fat-globules, which, of course, have here no significance, and are often seen folded or edgewise, when they are narrow,

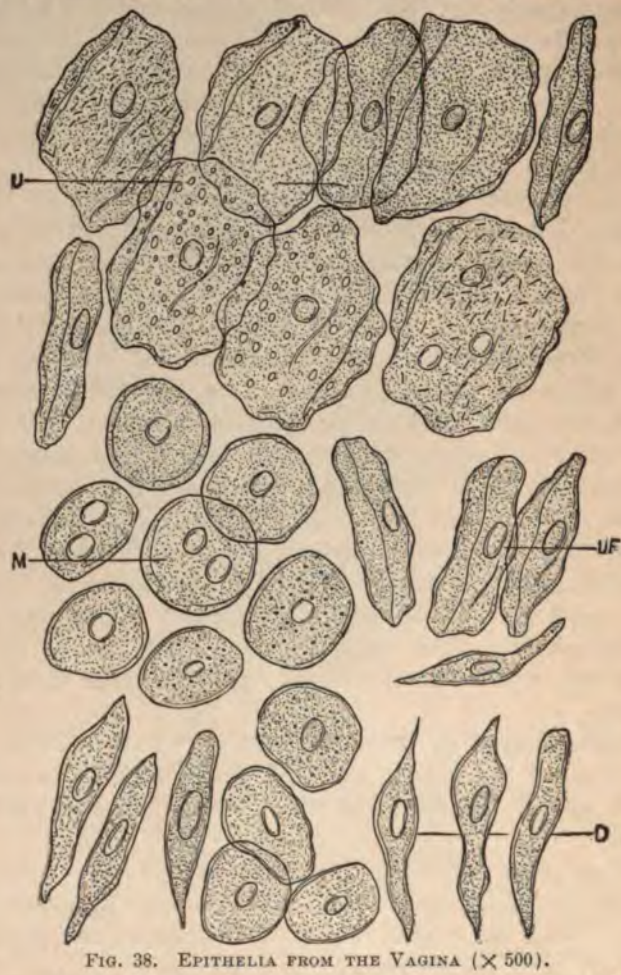

FIG. 38. EPITHELIA FROM THE VAGINA (× 500).

U, upper layers; U F, upper layers folded; M, middle layers; D, deepest layer.

but irregular, and can not be mistaken for columnar epithelia. Their granulation is fine, and the epithelia, therefore, pale.

The cuboidal epithelia from the middle layers are abundant in inflammations of the vagina. They are considerably larger than those from the bladder, have one or more nuclei, and, in chronic

inflammations, contain fat-granules and -globules. These are also found in clusters of considerable size.

The columnar epithelia from the deepest layer, much larger than those from the bladder, are seen only in intense, deep-seated inflammations or ulcerations, where they may sometimes be found in large numbers.

Smegma.—Of common occurrence in the urine of the female are clusters of epidermal scales, so-called smegma, partly from the clitoris, partly from the labia, or from the vagina. Smegma

FIG. 39. SMEGMA FROM THE CLITORIS (× 450).

may also be found in small amount in the male, from the prepuce, but here it is not so common, nor seen in such enormous masses as in the female (see Fig. 39).

Smegma consists of closely packed masses of variously sized epidermal scales filled to a greater or less degree with bacteria, —both cocci and bacilli,—and also with extraneous fat-globules, as well as particles of dirt. The individual scales, as before said, are never nucleated and rarely granular, but appear shrunken. Such masses, which have been seen to cover an entire field of the microscope, are highly refractive, and when large can be seen with the naked eye.

Epithelia from Bartholinian Gland (see Fig. 40).—The

epithelia from the Bartholinian gland are in every respect the same as those from the prostate gland in the male, being cuboidal and twice the size of pus-corpuscles. They are frequently present when the vaginal epithelia are found in moderate or large quantities.

Epithelia from Cervix Uteri.—Epithelia from the cervical portion of the uterus are partly flat, partly cuboidal, and partly col-

FIG. 40. EPITHELIA FROM BARTHOLINIAN GLAND, CERVIX UTERI, AND MUCOSA UTERI (× 500).

BE, Bartholinian gland; CE, cervix uteri; UE, mucosa uteri.

umnar, and quite large, though considerably smaller than those from the vagina, and always more irregular. These epithelia may be characteristic, but they sometimes so resemble the irregular epithelia from the urethra, as to be difficult of differentiation. The latter are found in the female as well as the male, though generally in smaller numbers.

Epithelia from Mucosa Uteri.—Epithelia from the mucosa of the uterus, indicating a catarrhal endometritis, are also not rare in the urine. They are delicate, columnar, ciliated formations, smaller than those described as being derived from the ejaculatory ducts. The cilia on the surface of these epithelia are frequently well marked, and as many as three or four may be found; occasionally, however, they are broken off. With them we may see ciliated pus-corpuscles, which arise from the epithelia, and can

not come from any other locality than the uterus. In freshly voided urine the cilia from both these formations may be seen in waving motion.

If the epithelia just described are carefully studied, we will soon become convinced that the formations from the different organs of the genito-urinary tract can undoubtedly be differentiated, and that diagnoses of the different lesions can be made with great certainty. In every case in which at least a moderate number of epithelia is found in the urine, most of these are characteristic of the organ from which they are derived. There will, of course, always be a few whose origin must remain doubtful, but these are not sufficiently numerous to cause errors. The more cases we examine, the more convinced we will become of this fact. The clinical history of the case will bear out the microscopical diagnosis every time, and frequently the microscope will give the first indication of some pathological condition which has as yet escaped detection, but which sooner or later is bound to give clinical symptoms. In no organ is this more pronounced than in the kidney, where mild cases of nephritis, which unfortunately escape detection for months or years, may be present, until suddenly the pronounced symptoms of a chronic nephritis or a cirrhosis of the kidney develop. Conscientious examination of the urine for kidney epithelia and pus-corpuscles will often repay the physician in cases where, although he has found a trace of albumin, he will banish from his mind, all idea of an inflammation of the kidneys because no casts are present.

Chapter X

MUCUS AND CONNECTIVE TISSUE

I. *MUCUS*

Mucus is found in small amount in every normal urine, being, as a rule, more abundant in females. It appears in the form of threads and corpuscles, and is a normal physiological product of the epithelia (see Fig. 41).

Mucus-threads are finely striated, pale, often scarcely perceptible strings of different sizes. In normal urine they are always small; but in inflammations, especially those of the genital tract, may assume large proportions. The strings are made up of pale, more or less parallel fibers, and when large, may branch in different directions.

Besides threads, mucus-corpuscles are of frequent occurrence. These corpuscles vary in size from that of a pus-corpuscle to that of larger epithelia; are pale, more or less irregular in outline, always finely granular and non-nucleated. They are easily distinguished from pus-corpuscles by their greatly varying sizes, pale appearance, and absence of a nucleus, which latter is seen in finely granular pus-corpuscles.

Mucus-threads not infrequently appear in the form of delicate, striated formations, resembling casts, the so-called cylindroids or mucus-casts (see Fig. 42). Although at times resembling hyaline casts, they can be distinguished from them by their irregular contours, enormous difference in size, and their more or less striated interior, since they are nothing but conglomerations of mucus-fibers. They may be found whenever mucus is present in larger amounts, and may be derived from any portion of the genito-urinary tract. They undoubtedly have no further significance than mucus in general.

Mucus is greatly augmented in all inflammatory conditions, but more especially in inflammations of the bladder and the genital organs, such as the urethra, prostate gland, and vagina.

In the latter, mucus-threads are often large, cylindrical, and twisted, and may be perceptible to the naked eye. The so-called gleet-threads are nothing but conglomerations of mucus, in which large numbers of pus-corpuscles and epithelia are imbedded.

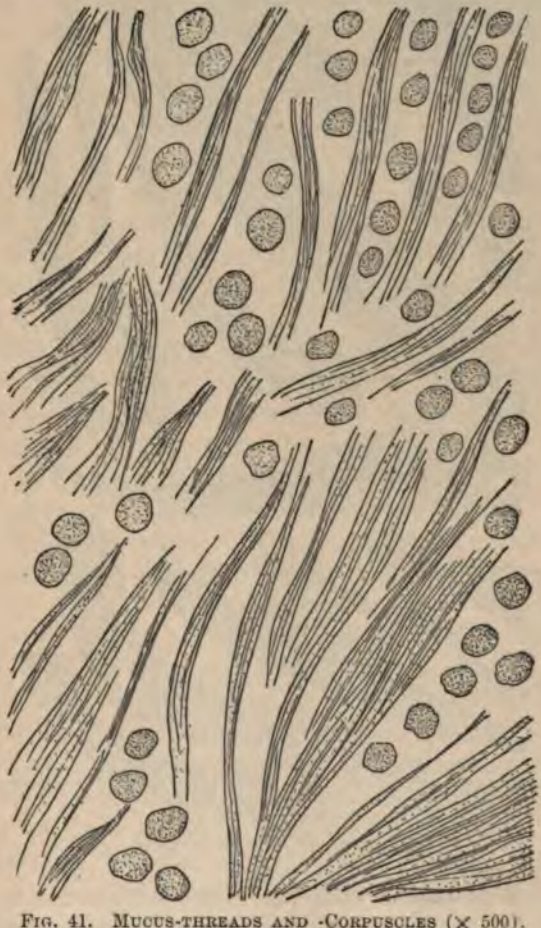

FIG. 41. MUCUS-THREADS AND -CORPUSCLES (× 500).

Irritation of the urinary tract, due to highly acid urine, containing uric acid and urate of soda, will increase the amount of mucus, and the urates being precipitated upon it, the stringy masses become more easily perceptible. Fat-granules and -globules, so frequently found in the urine, will also conglomerate upon mucus-threads and so-called cylindroids.

In chronic inflammations of the bladder, the urine will appear ropy on account of the abundance of mucus. Simple irritation of the sexual organs is sufficient to increase the amount of mucus,

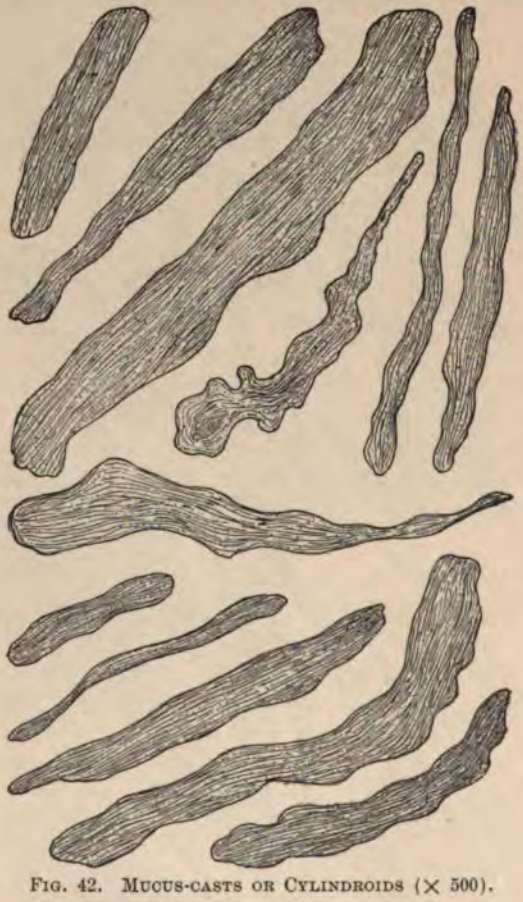

FIG. 42. MUCUS-CASTS OR CYLINDROIDS (× 500).

and if sperma is mixed with the urine, its mucous constituents appear as pale, flaky masses entangled with spermatozoa.

Finally, an increased amount of mucus may be seen in the urine in different febrile conditions, without any inflammation in the urinary tract, and in acute contagious diseases, such as scarlet fever, frequently appears as a precursor of a nephritis.

II. *CONNECTIVE TISSUE*

As all the organs containing epithelia also contain connective tissue, it is evident that this formation will frequently be found in the urine, though only in the more intense, deeper-seated pathological processes. Their occurrence has, however, been entirely overlooked, except in the rare cases in which particles of tumors, especially from cancers, have been found in the urine. That they are of comparatively common occurrence was first pointed out by Carl Heitzmann, who described their appearance under a number of different conditions. The reason for their being overlooked seems to be, partly, that in many cases they are small, though easily seen, and partly that they have been mistaken for mucus-fibers or extraneous substances, such as linen- and cotton-fibers.

Connective-tissue shreds (see Fig. 43) vary in size, and are made up of wavy, highly refractive fibers, the individual fibers being rarely single, but conglomerated in the form of small, irregular bundles, which again form larger bundles. These bundles, then, are always fibrillary and frequently finely granular, sometimes even containing formations resembling nuclei—the connective-tissue corpuscles. They may be so small and delicate as to entirely escape detection with a magnifying power of less than 500 diameters, or so large as to cover half or even the entire length of a field, and of varying thickness. They are easily differentiated from mucus-threads by their high refraction and their wavy, irregular fibers, in contradistinction to the pale appearance and more or less regular fibers of mucus, which frequently run in a parallel direction for a considerable distance. On the other hand, linen-fibers, or rather the smaller fibrillæ of linen, with which they might also be confounded, are of a still higher refraction, and are coarser, the individual fibrillæ being split up in an entirely different manner, and are never as wavy as the connective-tissue shreds.

The pathological conditions under which connective-tissue shreds are found may be divided into the following: (1) Ulceration, (2) suppuration, (3) hæmorrhage, (4) traumata, (5) tumors, (6) hypertrophy of the prostate gland with inflammation of that organ, (7) cirrhosis of the kidney, (8) atrophy of the kidney, (9) in all intense inflammatory processes, but in small amount only. As an example of the latter, the croupous or parenchy-

matous inflammation of the kidney may be mentioned, in which, if it is at all severe, connective-tissue shreds will be found in small numbers.

1. *Ulceration.*—Ulcerative processes are quite common occurrences, and may be found in any part of the genito-urinary

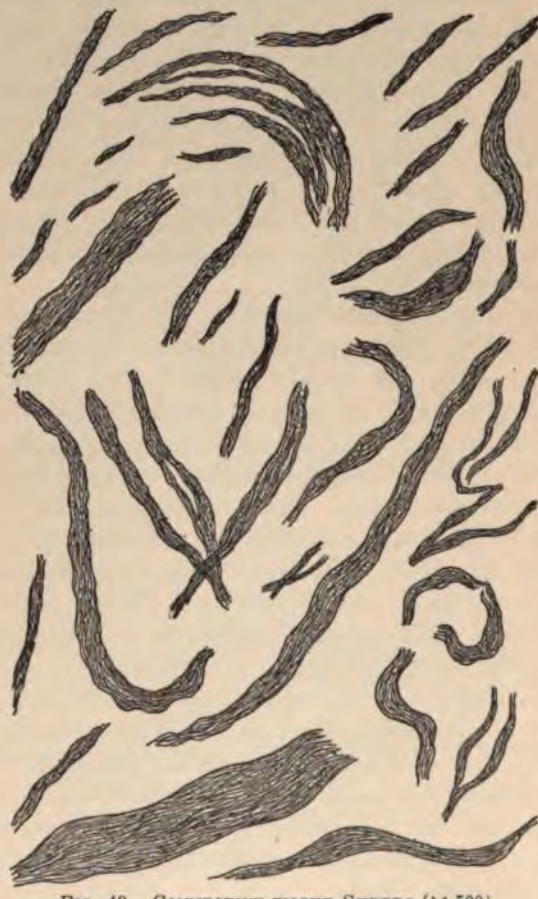

FIG. 43. CONNECTIVE-TISSUE SHREDS (× 500).

tract, but more especially in the bladder, pelvis of kidney, urethra, and vagina. In such ulcers the connective-tissue shreds are usually broad and numerous, pus-corpuscles will be present in moderate or fairly large numbers, and the location of the ulcer can always be determined by the presence of the characteristic epithelia, which are abundant, and not only found from

the more superficial, but also from the deeper layers. Besides these formations, the freshly voided urine will contain variously sized conglomerations of cocci, in the form of zoöglœa masses, especially around the connective-tissue shreds, as well as small numbers of other bacteria.

2. *Suppuration.*—The presence of an abscess in any organ can be diagnosed when connective-tissue shreds in large numbers are seen with numerous pus-corpuscles and epithelia from the organ in which the abscess is situated, this being most frequently either the kidney, the pelvis of the kidney, or the prostate gland. In many cases we will also see pronounced endogenous new-formations in the epithelia of the neighboring organs, as the result of pressure upon that organ. An abscess of the prostate gland, for instance, may give endogenous new-formations in the epithelia of the bladder, as well as of the urethra. Large numbers of pus-corpuscles and epithelia alone, without the presence of connective-tissue shreds, are never sufficient to diagnose an abscess. As soon, however, as these shreds, showing a destructive process, are found, the diagnosis will become plain. The connective-tissue shreds, although always quite numerous, may vary considerably in size.

3. *Hæmorrhage.*—In hæmorrhages of the genito-urinary tract, it is often quite difficult to find the epithelia showing their source—the more abundant the hæmorrhage, the greater the difficulty. It sometimes requires hours to arrive at a definite conclusion, though a certain number of epithelia will always be found sooner or later. In all such cases connective-tissue shreds are present, but are occasionally quite scanty and small, except when the hæmorrhage is due to a tumor. They have, as a rule, a yellowish tint, from the coloring matter of the blood. In hæmorrhages red blood-corpuscles are very abundant, and white blood-corpuscles are generally seen in small numbers. Strings of fibrin, which must not be mistaken for connective tissue, are found in many of these cases, but pus-corpuscles are absent as long as there is no inflammation; if a hæmorrhage intervenes upon an inflammation, all the evidences of the latter will, of course, be present with the former.

4. *Traumata.*—Since traumata, due to various causes, are frequently accompanied by hæmorrhages or even ulcerations, their symptoms would be those above given. There are, however, cases in which the injury does not cause a pronounced hæmorrhage,

yet the destructive process to the tissue is sufficient for connective-tissue shreds to appear in the urine, with but a few red blood-corpuscles. Among these may be mentioned slight injuries, due to the passage of a small amount of gravel, mechanical injury of the orifice of the vagina due to masturbation, or injuries of the cervix uteri. In mechanical injuries, such as are caused by masturbation, vaginal epithelia from all three layers will be found, together with a large number of epidermal scales from the labia, usually containing fat-globules, epithelia from the Bartholinian gland, a few pus-corpuscles, possibly a few red blood-corpuscles, and a small or moderate number of connective-tissue shreds. When the number of vaginal epithelia is not large, and connective-tissue shreds appear with numerous irregular epithelia from the cervix, with only a few pus-corpuscles, injuries around the cervix are indicated. Although of comparatively small practical importance, it must be known that connective-tissue shreds in the urine of females may be due to such causes.

5. *Tumors.*—In all tumors which can be diagnosed from the urine, such as papilloma, sarcoma, and cancer, connective-tissue shreds are the most important diagnostic features, without which the presence of a tumor can not be positively diagnosed. Besides these, other evidences of a tumor are frequently found, though the connective-tissue shreds themselves may be characteristic enough for a diagnosis.

In papilloma, such shreds are always large, very irregular, frequently branched, and often assume the shape of coils or knobs (see Fig. 44). They are coarsely granular, and may contain a number of inflammatory corpuscles in their interior. In rare cases, blood-vessels in process of formation or fully developed may also be found in them. Besides these large masses, the regular connective-tissue shreds are also present in varying amount. A number of irregular, coarsely granular epithelia, the covering epithelia of the papilloma, will usually be seen in such cases, though they are not found in situ, and are not of much value for a diagnosis.

In cancer of the bladder, especially villous or papillary, the connective-tissue shreds are occasionally still larger and more irregular, forming regular cauliflower-like excrescences. They are infiltrated with inflammatory corpuscles, sometimes to a great degree, and often contain large cancer epithelia or even epithelial nests. Besides these shreds, such cases contain a varying number

of epithelia about the size of those from the middle layers of the bladder, but extremely irregular, coarsely granular, and having numerous nuclei or pus-corpuscles in their interior,—the so-called endogenous new-formations. In rarer cases, variously sized cancer nests are also present. As a rule, both the connective-

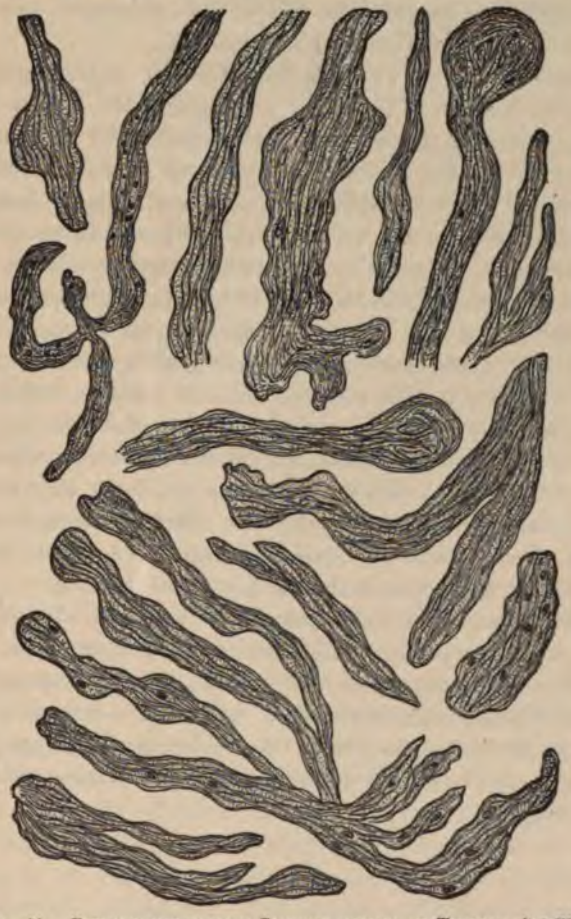

FIG. 44. CONNECTIVE-TISSUE SHREDS FOUND IN TUMORS (× 500).

tissue shreds and the epithelia are seen crowded with fat-globules and -granules. The epithelia alone are never sufficient for a diagnosis, but as soon as the shreds just described are present the case becomes plain. That pus-corpuscles, bladder epithelia, and, usually, red blood-corpuscles are always found in these tumors, is evident.

In sarcoma, which can develop either in the kidney, bladder, prostate gland, or uterus, and be diagnosed according to the epithelia present, the connective-tissue shreds are frequently of very large size, but not characteristic. Here peculiar, glistening, coarsely granular, almost homogenous corpuscles, smaller than pus-corpuscles but larger than red blood-corpuscles, are found in large numbers and variously sized groups.

6. *Hypertrophy of Prostate Gland.*—An enlargement of the prostate gland, when slight and unaccompanied by an inflammation, will not give connective-tissue shreds in the urine. As soon, however, as the hypertrophy becomes more pronounced and is accompanied by an inflammation, connective-tissue shreds, which may be small and scanty, will invariably appear in the urine, with pus-corpuscles and epithelia from the prostate gland. Besides these features, we will usually find the endogenous new-formations in the epithelia of the bladder or urethra, or both.

7, 8. *Cirrhosis and Atrophy of Kidney.*—Every chronic interstitial nephritis will, sooner or later, lead to cirrhosis of the kidney, and every chronic parenchymatous nephritis to atrophy of the kidney. In both of these affections, connective-tissue shreds are also present, usually in small amount only in cirrhosis, but always in larger amount in atrophy. The features found in the urine in these diseases, besides connective-tissue shreds, are numerous and so constant that a diagnosis is simple.

9. That connective-tissue shreds will also be found in small numbers in every intense inflammation, is evident from what has been said. Tuberculosis of the kidney, for instance, even if as yet unaccompanied by ulceration, will give a few shreds in the urine. As soon as connective-tissue shreds, however small, are found, it becomes evident that the pathological process can not be a mild one.

Chapter XI

TUBULAR CASTS

Tubular casts were first carefully described as occurring in the tubules of the kidney and found in the urine by Henle in the year 1842, although they were probably seen a few years before that time by different observers. Many years later, in 1867, Rovida gave a thorough account of their nature and formation. Henle considered them to be coagulated fibrin, but the views concerning their origin have become greatly changed since that time. They were at one time considered as products of secretion of the epithelia of the tubules, at another time as transformed or disintegrated epithelia. Later on, the blood-vessels were supposed to be principally concerned in their production, at least in that of the hyaline casts, without any participation of the epithelia.

One of the older views was that casts are produced by the coagulation of an albuminous substance, the supposition being based upon the fact that the presence of casts in the urine depends upon the admixture of albumin, since they are found in conditions accompanied by albumin, and the more abundant the albumin, the more likely casts will be present. This view seems to be nearly correct. Casts are probably the products of an albuminous exudation from the blood-vessels, with the addition of the swollen and destroyed epithelia. In almost all cases where casts are present, albumin is found in moderate or large amount; but there are undoubtedly cases in which the amount of albumin is small, and, it is claimed, may even be entirely absent. The latter is, however, doubtful. The amount of albumin may be so small as to escape detection by the usual chemical methods employed; but, according to the view of their formation, it would seem that a small amount, at least, must be present in every case.

The appearance of casts in the urine is always of the highest diagnostic importance, and, if found in any amount, they indicate the presence of a croupous or parenchymatous nephritis, the more

so, the larger the accompanying amount of albumin. It is asserted that a mere hyperæmia of the kidneys will suffice to throw casts into the urine, and also that casts can be found in small numbers when the kidneys are perfectly intact. They have been described in cases of gastro-intestinal catarrh, in jaundice, acute and chronic anæmia, as well as in nervous affections of different kinds, without any accompanying inflammation of the kidneys. As they have been found in very small numbers only in all such cases, it is an open question whether true casts were seen, or only cylindroids, which at times it is almost impossible to distinguish from hyaline casts. Since casts are always the products of an inflammatory process, they can hardly be found in plain hyperæmia of the kidney, unaccompanied by an inflammation.

In order to positively guard against any errors in the diagnosis, it is important to always look for other evidences of inflammation in the urine, when casts are believed to be present. As soon as they are found, the nature of the formations is plain. Great difficulty seems to exist sometimes in finding casts, even when they are known to exist, since, at times, they will not settle for a number of hours. If urine is allowed to stand for at least six hours, and is then carefully decanted, the casts, if any are present, will surely be found in the sediment at the bottom of the vessel. Attention should also be called to the fact that low magnifying powers are unreliable for the detection of casts, and that a power of at least 400 diameters should always be used. Another necessary precaution is to examine more than one specimen before positively determining as to the presence or absence of casts. With a little care, the centrifuge can undoubtedly be used, but unless it is of great importance to examine a specimen of urine at once, the older method is preferable.

Casts have been divided in many different ways, but, perhaps, the simplest is to divide them into *true casts* and *false, or pseudo casts*. The former alone denote the presence of a nephritis, while the latter are accidental formations.

I. *TRUE CASTS*

True tube casts are of six varieties. These are: (1) Hyaline casts, (2) epithelial casts, (3) blood casts, (4) granular casts, (5) fatty casts, (6) waxy casts.

Generally speaking, the first three varieties,—hyaline, epithe-

lial, and blood casts,—are found only in an *acute* parenchymatous or croupous nephritis, while the last three,—*i.e.*, granular, fatty, and waxy casts,—are found only in a *chronic* parenchymatous inflammation of the kidney. In the first few weeks of the inflammation, the last three varieties of casts never appear; but as soon as the absolutely acute attack commences to subside, and the inflammation assumes a more subacute form, granular casts, first in small, then in larger numbers, are seen, while the hyaline and epithelial casts are still abundant. Fatty and waxy casts are always secondary products, and are never found until a nephritis has lasted for some time, although mixed epithelial and granular casts, commencing to become fatty, may be found five or six weeks after the beginning of the inflammation.

All true casts may appear in three distinct sizes, according to the portion of the uriniferous tubules from which they originate. The narrowest casts are those formed in the narrow tubules, the next in size from the convoluted tubules of the second order, while the largest are always formed in the straight collecting tubules. Casts from the convoluted tubules of the first order, those directly arising from the capsule of the tuft, never appear in the urine, since they can not pass the narrow tubules.

Although not generally admitted, a great prognostic value undoubtedly attaches to the size of the casts. The mildest degrees of the disease are indicated by casts from the narrow tubules, and a small number of casts from the convoluted tubules. Not infrequently pedunculated casts are met with; that is, formations from the place of transition of the narrow tubules into the convoluted tubules of the second order. Casts from the convoluted tubules justify the diagnosis of parenchymatous nephritis in the cortical substance. Casts of all three sizes, the largest arising from the straight collecting tubules, permit of a conclusion of parenchymatous nephritis in the whole organ, and upon this condition a very unfavorable prognosis can be established.

Based upon these simple facts, a good or a bad prognosis can be given in many cases where the clinical features are too obscure to be of any practical value, and in a number of cases the bad prognosis, which had to be given on account of the presence of many large casts from the straight collecting tubules, and which did not at first seem justified by the scarcity of clinical symptoms, was soon borne out by the fatal end of the case.

That, besides these facts, stress must always be laid upon the general constitution of the patient, which, as previously explained, can be positively recognized by the appearance of the pus-corpuscles, need hardly be mentioned again. A careful examination of all the pus-corpuscles present in a given case

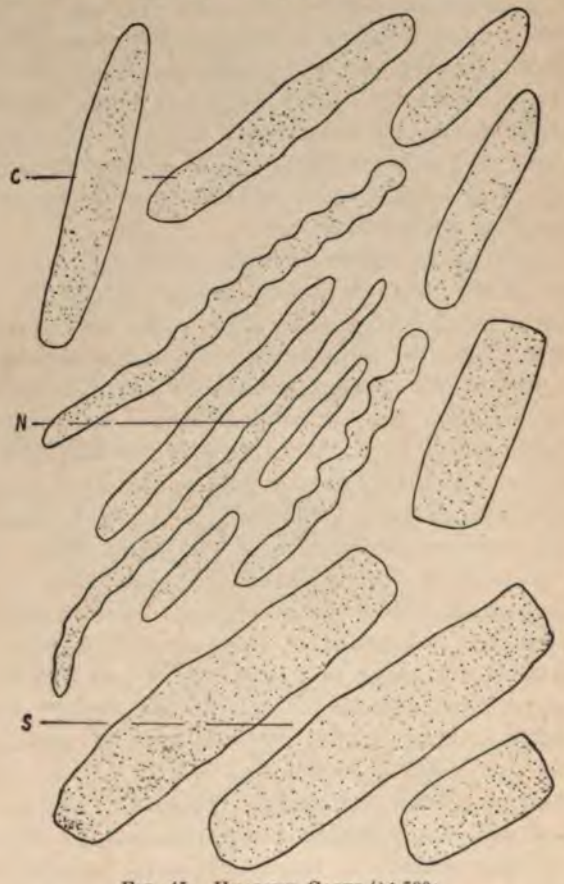

FIG. 45. HYALINE CASTS (× 500).

C, casts from convoluted tubules; N, from narrow tubules; S, from straight collecting tubules.

will invariably show how much the constitution has been impaired by disease; the paler the pus-corpuscles the more unfavorable the prognosis, and, therefore, the worse the constitution of the patient at the time of examination.

1. *Hyaline Casts* (see Fig. 45).—Hyaline casts are pale formations of variable length, sometimes of considerable size, and

not infrequently difficult of detection in the urine. Those from the convoluted and straight collecting tubules are usually more or less regular, though the latter may be very broad; those from the narrow tubules are occasionally tortuous or spiral, and at times exceedingly narrow and delicate. As a rule, these casts

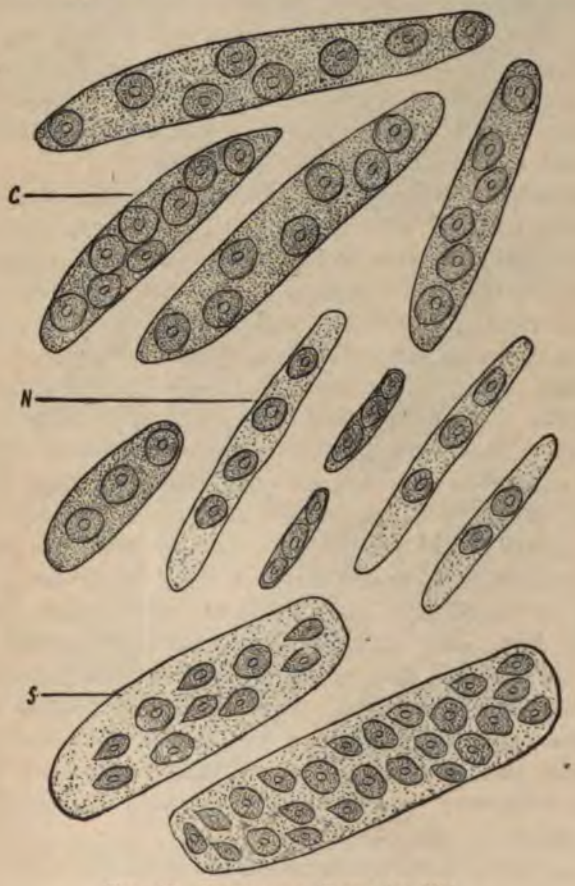

FIG. 46. EPITHELIAL CASTS (× 500).

C, casts from convoluted tubules; N, from narrow tubules; S, from straight collecting tubules.

are absolutely structureless, but at times a pale granulation is noticeable in their interior, though this is not sufficiently marked to allow of their classification as granular casts. Different formations, such as pus-corpuscles and fat-globules, may be seen upon them in small numbers, but are accidental, and do not

change the diagnosis. In rare cases these casts may appear more solid and of higher refraction, though their hyaline character is undoubted, and they must not be mistaken for waxy casts.

When very delicate and pale, it has been advised to color the casts by the addition of a drop of iodine-iodide of potash solution (iodine, 1 part; iodide of potash, 2 parts; water, 300 parts) upon the slide, which will stain them yellow, and render them more distinct. This is rarely necessary, since a sharp focus, perhaps with the light somewhat shaded, will bring them into view quite clearly. In a highly alkaline urine they are indistinct, and after a time seem to become lost completely.

2. *Epithelial Casts* (see Fig. 46).—True epithelial casts are hyaline casts studded with epithelia. The desquamated epithelial tubes which are sometimes found in the urine, and represent solid masses of epithelia of varying length in the form of casts thrown off from the tubules, can hardly be called true casts, although they are usually classified as such.

Epithelial casts, when present, always denote an acute process, and the more pronounced it is, the larger is the number of these casts. They vary in size according to their origin, but are never as long as some hyaline casts, and are usually quite regular. They are of a higher refraction than the former, and can be easily found. The number of epithelia seen in these casts varies considerably. Sometimes no more than two, three, or four will be found in a cast, while at other times the cast is completely filled with them, though still showing its structure plainly. Those from the convoluted and narrow tubules contain the spherical epithelia, while those from the straight collecting tubules are usually filled with a number of columnar epithelia. Occasionally these casts have a yellowish color and a slightly increased refracting power, owing to their imbibition of the coloring matter of the blood.

As long as the nephritis is acute, the epithelial casts will have the appearance just described, being more or less coarsely granular, but with the epithelia perfectly intact. As soon as the inflammation enters the subacute or chronic stage, their character changes and fat-globules appear. We can then no longer consider them pure epithelial casts.

3. *Blood Casts* (see Fig. 47).—The presence of blood casts in the urine always shows a hæmorrhage within the tubules of the kidney, and when seen in large numbers, the complication is quite

grave; but less so in children than in adults. The appearance of these casts varies greatly; they are always more irregular than the epithelial casts, their ends more or less rounded, and may be

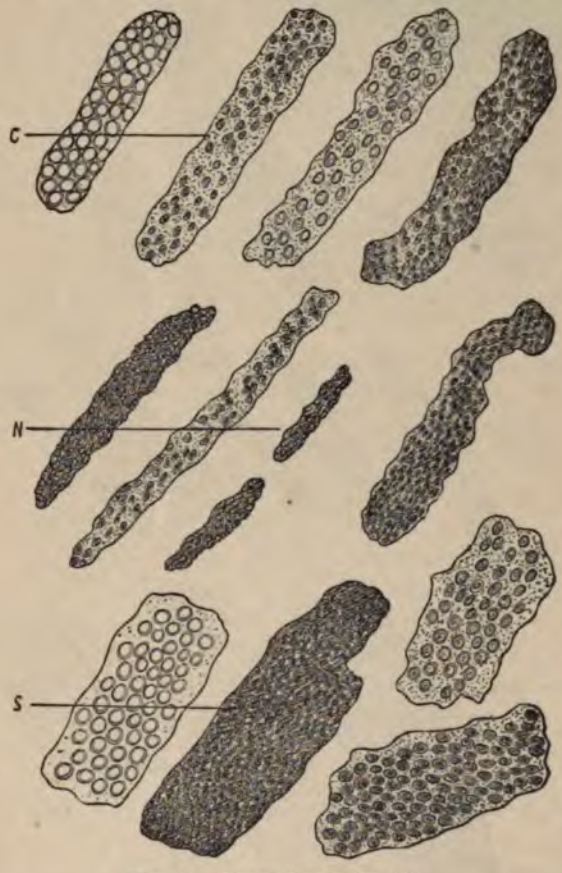

FIG. 47. BLOOD CASTS (× 500).

C, casts from convoluted tubules; N, from narrow tubules; S, from straight collecting tubules.

either studded with a varying number of red blood-corpuscles without changing their color; or, if they have been retained in the tubules for some time, the blood-corpuscles lose their shape, and the casts take on the appearance of dark, rust-brown, granular clusters.

Many of these casts will show transitional forms and have a more or less pronounced color. They always indicate an acute hæmorrhagic process, and usually we find either hyaline or epi-

thelial casts, or both, with them. Besides these, conglomerations of fibrin, the so-called fibrin casts, are occasionally found, but, properly speaking, they are not true casts. In still rarer cases,

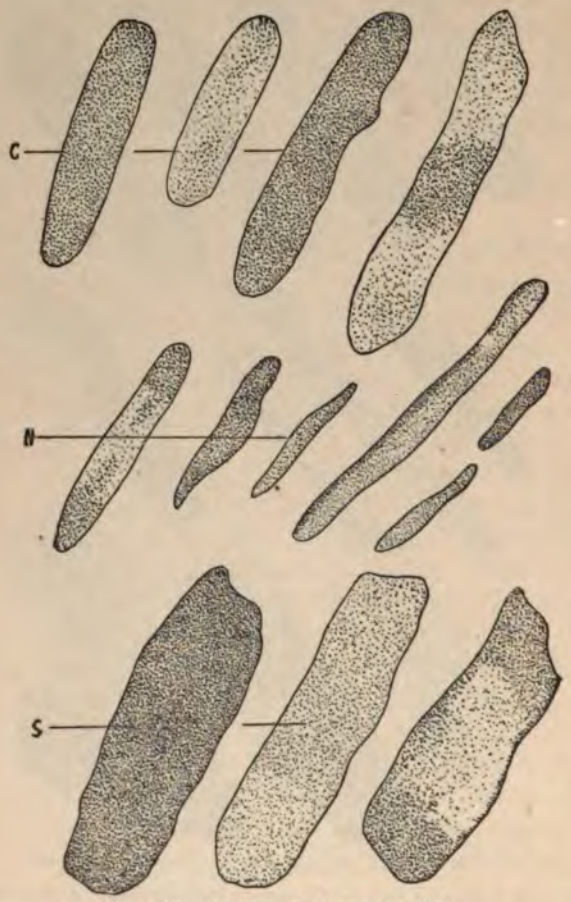

FIG. 48. GRANULAR CASTS (× 500).

C, casts from convoluted ubules; N, from narrow tubules; S, from straight collecting tubules.

such as hæmoglobinuria, casts of hæmoglobin, resembling the disintegrated blood casts, but much more irregular and granular, and of a darker color, are seen.

4. *Granular Casts* (see Fig. 48).—While the three varieties of casts just described are always found in acute cases, or fresh acute recurrences of chronic inflammations, granular casts never appear

in strictly acute inflammations. As a rule, they will not commence to be formed until a number of weeks after the beginning of the disease; but in some cases, especially in children after scarlet fever and diphtheria, they have been seen in small numbers two or three weeks after the first symptoms of the nephritis have set in.

Granular casts are either perfectly regular and have sharply defined contours, or they are more or less curved, or appear curved at one side while they are straight at the other. Their ends are either rounded or partly broken, and they may be broader at one place and narrower in another—a peculiarity especially pronounced in those from the narrow tubules. Their degree of refraction changes considerably, and they sometimes appear yellowish, at other times colorless.

The granulation of these casts varies to a great degree, some being coarsely granular, others finely granular, still others partly the former and partly the latter. They may appear coarsely granular at both ends, finely granular in the center, or finely granular above and below and coarsely granular in the center, the gradations being many.

Granular casts are always due to a disintegration of the kidney-epithelia, which will commence after a varying length of time. In those cases which have not as yet become chronic, the disintegration of the epithelia can be studied under the microscope in all the different stages. In cases of long duration, the granules become changed into glistening fat-granules and -globules.

5. *Fatty Casts* (see Fig. 49).—True fatty casts are always secondary products of epithelial and granular casts, therefore their size and shape resemble the former considerably. The substance of all the casts so far mentioned is the same, the difference in appearance being given by the outer adhering formations. Conglomerations of variously sized, sometimes large, fatty globules, without well marked contours, showing their original substance, can not be classed as true casts.

Fatty casts contain a varying number of small, glistening fat-globules and -granules, which give to the cast a high refraction, the cast being either completely or partially filled with them. As they are secondary products only, it follows that, even when they are present in small numbers, the diagnosis of a chronic process is justified; the more so, the more completely they are formed. The commencement of their formation can frequently be seen in both

epithelial and granular casts, the granules becoming more glistening and highly refractive, and finally changing to globules. When the casts are present in large numbers, they always denote a pronounced fatty degeneration of the kidney, as found in the large white kidney.

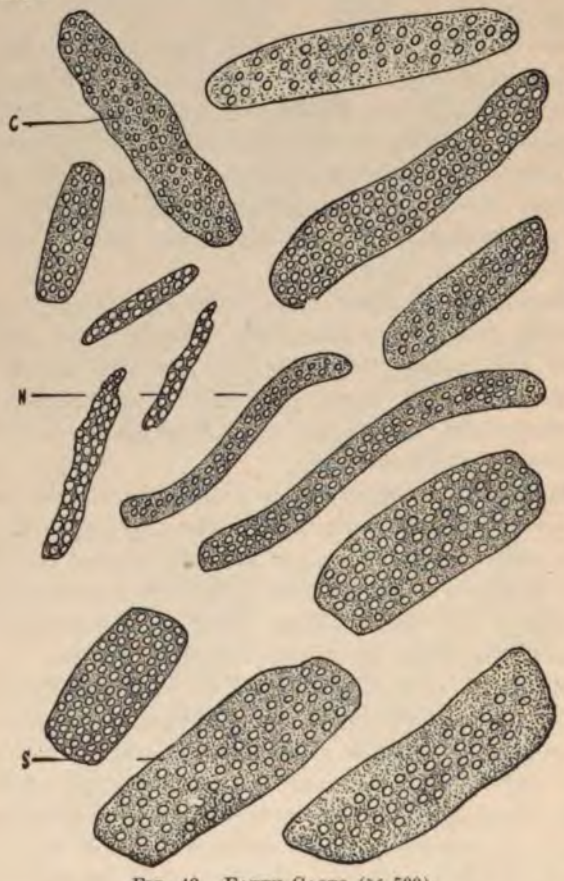

FIG. 49. FATTY CASTS (× 500).

C, casts from convoluted tubules; N, from narrow tubules; S, from straight collecting tubules.

6. *Waxy Casts* (see Fig. 50).—Waxy casts are different in their chemical nature from hyaline casts; they are characterized by wavy, fluted contours, a high refracting power, a more or less yellowish color, and a high degree of brittleness. They vary greatly in size, and are always more or less irregular, on account of their frequently broken contours. Sometimes their wavy,

fluted appearance is extremely pronounced, and they may resemble regular cork-screw windings.

When all these characteristics are present the diagnosis of a waxy cast is plain, and such a cast will never appear in acute

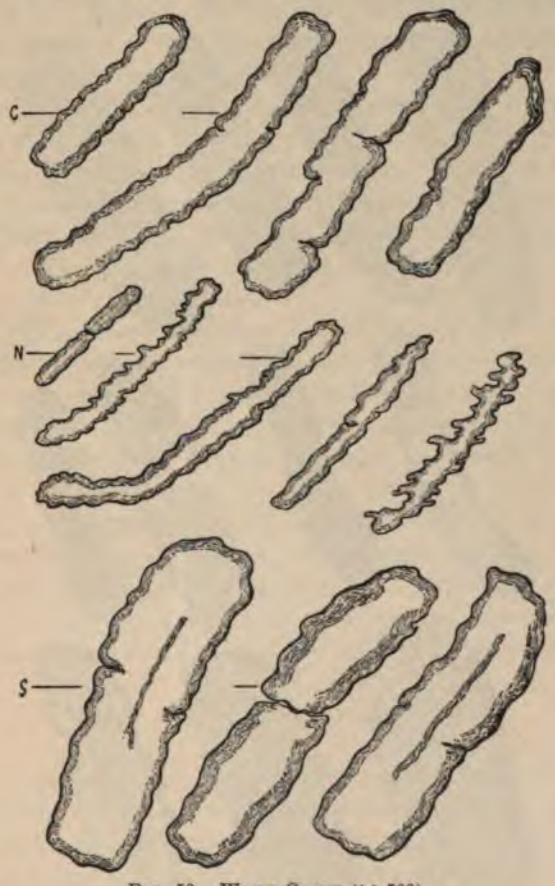

FIG. 50. WAXY CASTS (× 500).

C, casts from convoluted tubules; N, from narrow tubules; S, from straight collecting tubules.

inflammations, but only in chronic processes, which, if the casts are at all numerous, are always intense. They invariably signify waxy degeneration of the kidney. Sometimes hyaline casts exhibit spiral windings, and may somewhat resemble waxy casts. These spiral windings are probably due to their having originated in the spiral portion of the ascending branch of the loop-tubule, and

have no special significance. Such hyaline casts never have the same high refraction as the waxy casts, and a little care is sufficient to differentiate them from each other.

Pure waxy casts may be found studded with different formations, which, of course, will not change the character of the cast.

FIG. 51. MIXED CASTS (× 500).

At times they are of extremely large size, and may then be almost entirely broken in different portions.

7. *Mixed Casts* (see Fig. 51).—In a large number of cases, when casts are present, these casts will not appear in their true form, but may be more or less mixed. Any two, three, or four varieties may be so intermingled as to be difficult of differentiation. The more common of these forms will be found in Fig. 51.

In the first row, the first cast shows an epithelial-granular-fatty variety, with the epithelia perfectly intact, while the other casts partly show how the epithelia break down and become disintegrated into granules and fat-granules and -globules, partly the change of granular into fatty casts. The disintegration of the epithelia, in the manner here depicted, is frequently seen in subacute inflammations. The change of granular casts into the fatty kind is seen in chronic processes.

In the second row, combinations of waxy casts are shown, the first being a fatty-waxy; the second, a granular-fatty-waxy, while the third and fourth are blood-waxy casts. The first cast in the third row is an epithelial-blood cast; the second a blood-epithelial-granular-fatty cast, and the third an epithelial-granular-fatty-waxy cast. The diagnosis of a case does not, of course, become altered by these combinations.

Other Casts.—Besides these six varieties of casts, the mucus-casts or cylindroids, previously described, are occasionally placed among the true casts; that they do not have any special significance has already been stated. They may contain a varying number of fat-globules, but their striated, irregular appearance is sufficient to clear up the diagnosis.

Again, a separate variety of casts is described as being derived from the seminal tubules. These casts are said to resemble hyaline casts, but to differ from them in their larger size, greater breadth, and greater irregularity. They are, however, nothing but cylindroids, and, as such, have no special significance.

II. *FALSE OR PSEUDO CASTS*

False or pseudo casts are not infrequently found in the urine, and have no connection whatever with diseases of the kidney. These formations are mostly conglomerations of different substances upon mucus-threads or -casts, or accidental formations in the shape of casts. When true casts, especially of the hyaline variety, are present, together with an abundance of urates, the latter may undoubtedly be found upon the casts to such a degree as to render a diagnosis of the original cast doubtful.

Urate Casts (see Fig. 52).—Among these formations, conglomerations of urates, sometimes called uric acid casts—although uric acid, as such, rarely enters into their structure—as well as casts of urate of sodium, are not infrequently found. The for-

mer, consisting of conglomerations of urate of ammonium, are described as occurring only in infants, and forming in them small, reddish brown masses, apparent to the naked eye; but they are also seen in adults, although very rarely. Formations of urate of sodium, resembling casts, may at times be mis-

FIG. 52. CASTS OF URATE OF AMMONIUM AND URATE OF SODIUM (× 500).

taken for granular casts; but they have the characteristic yellowish brown color of urate of sodium, and show no outlines in many cases. When the masses of urate of sodium are not heavy, mucus-threads or -strings can be distinctly seen underlying them. Besides these, we may also see such formations composed of urate of sodium in transition to urate of ammonium. When this transition has not advanced far, granules as well as small globules and dumb-bells are plainly visible; but if, on the other hand, the granules have all become changed to globules and dumb-bells, care should be taken not to mistake them for disintegrated blood casts. Here, too, the absence of a contour, as

well as the color of the urates, will be sufficient for a diagnosis.

Among the other pseudo casts, the more common are bacterial, pus, fat, and fibrin casts (see Fig. 53).

Bacterial Casts.—Bacterial casts are frequent occurrences, especially when the urine has been allowed to stand in a warm

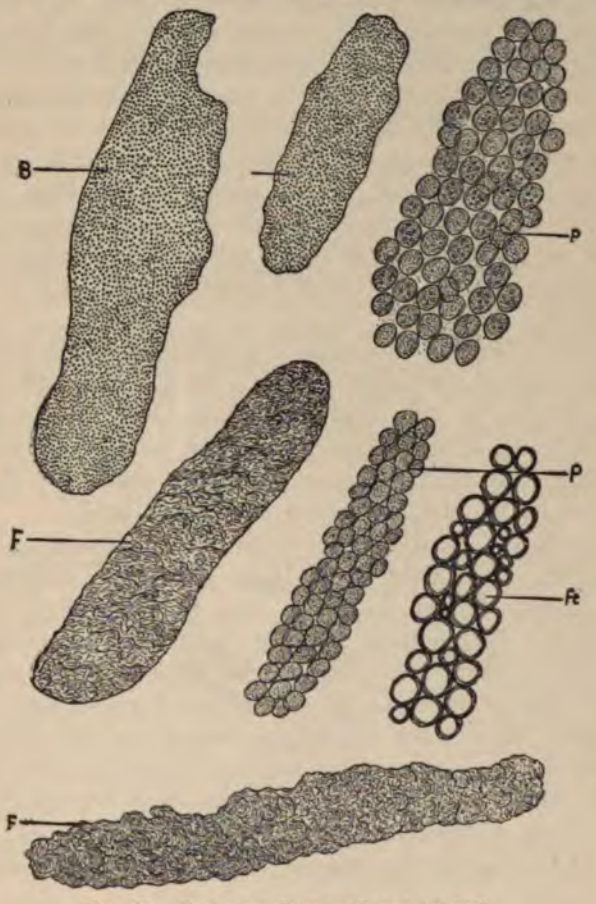

FIG. 53. FALSE OR PSEUDO CASTS (× 500).
B, bacterial casts ; P, pus casts ; Ft, fat cast ; F, fibrin casts.

room for twelve hours or more, so that a large number of bacteria have developed. They undoubtedly resemble granular casts so much as to sometimes require a sharp focusing for their differentiation. They may vary considerably in size, but their outlines are pale and more or less irregular, and they are composed

of masses of micrococci, not of granules. They have no significance whatever, except when found in perfectly fresh urine as an aid to diagnosis, where they are most likely to be seen in severe inflammatory or suppurative processes. As a rule, the micrococci become deposited upon mucus-threads. In order to clear up their diagnosis, it may, in rare cases, be necessary to add a drop or two of some strong mineral acid or alkali, to which they will be seen to have a great resistance.

Pus casts.—Pus casts—that is, cast-like conglomerations of pus-corpuscles, usually upon mucus—are found in some cases. The pus-corpuscles may be massed together, with no outlines visible, or they are more loosely arranged, and may contain a number of small fat-globules. Pus-corpuscles may, of course, be found in small numbers upon different true casts, such as hyaline or epithelial, but such formations can not be classed as pus casts.

Fat casts.—Pseudo fat casts are rare, but have been found in a few cases of so-called lipuria. They consist of large fat-globules, having a very high refraction, and occasionally containing margaric acid needles. Again, a number of extraneous fat-globules upon mucus-threads have been seen; but these have a yellowish color, and can easily be differentiated.

Fibrin casts.—Lastly, fibrin casts may be found in cases of hæmorrhage. They may be of large size, have irregular, more or less sharply defined contours, and a yellowish or yellowish brown color. They consist of small, wavy, irregular fibers, and never occur without the presence of characteristic strings or bands of fibrin. In cases of hæmorrhagic parenchymatous nephritis, true blood casts are always associated with them.

Besides hæmoglobin, which may occur in the form of casts, two other varieties of pseudo casts have been described, namely, pigment and cholestearin casts. Peyer has seen one specimen of each of these, but they are the rarest formations in urine.

CHAPTER XII

MICRO-ORGANISMS AND ANIMAL PARASITES

I. *MICRO-ORGANISMS, OR FUNGI*

Perfectly fresh, absolutely normal urine never contains micro-organisms or bacteria, though they may develop in a short time after the urine is voided. In diseased conditions, on the other hand, bacteria may be present in large numbers when voided; such urine is always more or less turbid. Sometimes a number of micro-organisms may be found in otherwise normal urine, especially in that of the female from the vagina. In cases where so large a number of bacteria is voided with the urine as to render it turbid, the designation *Bacteriuria* may be used.

The development of bacteria in urine may be slow or rapid, depending partly upon the reaction and partly upon the temperature. In an alkaline urine they develop rapidly, and in a warm temperature may be found in large numbers one or two hours after the urine is voided. Bacteria present when the urine is passed are derived partly from the blood and partly from the different portions of the genito-urinary tract.

Micro-organisms seen in urine may be divided into non-pathogenic and pathogenic. The former may belong either to the class of mould-fungi, to that of yeast-fungi, or to that of fission-fungi, while the latter belong to the class of fission-fungi.

Non-pathogenic Micro-organisms.—1. *Mould-fungi.*—Mould-fungi or *hyphomycetæ* found in urine are either *oidium*, *penicillium glaucum*, or one of the *aspergilli*, the latter being comparatively rare. These fungi will be seen only in acid urine, or urine which was originally acid, even though it has become alkaline.

The most common of the hyphomycetæ is the *oidium lactis*, composed of conidia and mycelia (see Fig. 54). It easily develops in small numbers in urine of a highly acid reaction, and can be seen with the naked eye, in the form of whitish masses, only when present in large amount. Such urines contain a varying

number of small globules, in which frequently a central so-called vacuole is observed, together with threads of mycelia, either narrow and short, or quite large and branching. The globules are the spores or conidia, and care must be taken not to mistake

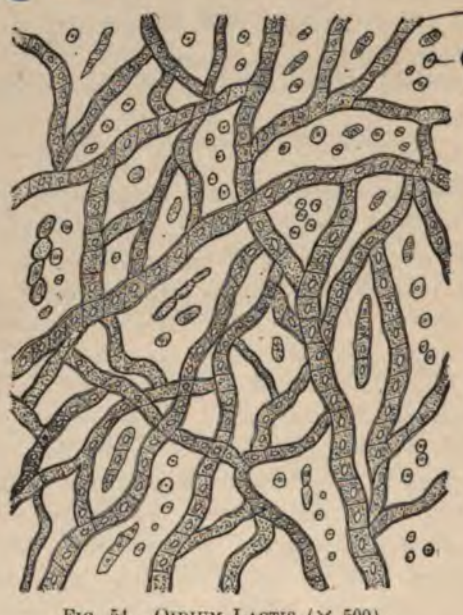

FIG. 54. OIDIUM LACTIS (× 500).

them for red blood-corpuscles or even fat-globules, which might easily be done. They vary in size, and can generally be distinguished by the central vacuole. The threads are the mycelia, which are, as a rule, coarsely granular and segmented, and contain a number of spores.

Besides the oidium lactis, both the penicillium glaucum and different varieties of aspergilli may be found in the urine, the former being quite common (see Fig. 55). The diagnosis of penicillium or aspergillus can be made only by the characteristic division of the hyphæ. In penicillium glaucum, the most common mould-fungus, the hyphæ divide and subdivide into thread-like formations,—the basidia and sterigmata,—the ends of which latter are surmounted by a number of spores or conidia. In the aspergilli no division takes place, but the hypha terminates in a spherical or club-shaped vesicle, from the periphery of which a number of short flask-like formations,—the sterigmata—are

visible, each of which contains a single spore upon its upper end.

2. *Yeast-fungi* (see Fig. 56).—The yeast-fungi or *saccharomycetæ* are found in acid urine, and are most frequently seen in

FIG. 55. PENICILLIUM GLAUCUM AND ASPERGILLI (× 500).

The upper half of the drawing shows the penicillium glaucum, the lower half different varieties of aspergilli found in urine.

those containing sugar, where they may be present in large numbers. They consist of variously sized globules or cells, the larger of which contain a smaller globule or nucleus. They never form mycelia, but multiply by sprouting or budding. The

globules have an oval or round shape, lie either singly, in twos, or in groups of different sizes, and are frequently beaded. In the larger globules, the process of budding can be plainly seen. The smaller globule, or daughter-cell, sprouts out from the larger or mother-cell, becomes an independent formation, grows, and, in its turn, forms a mother-cell. These globules may undoubtedly

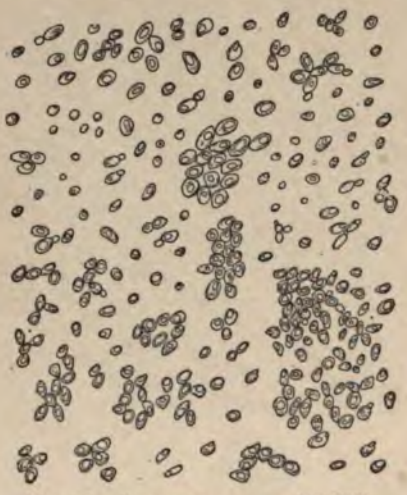

FIG. 56. SACCHAROMYCETÆ (× 500).

resemble blood-corpuscles, but their irregular size and shape, together with the presence of the nucleus, will be sufficient to differentiate them.

3. *Fission-fungi* (see Fig. 57).—The fission-fungi or *schizomycetæ* are rarely seen in highly acid urine, but frequently in urine which is becoming alkaline or has already undergone an alkaline change, and is showing putrefaction. When they are present in large numbers the urine is always cloudy, and both cocci and bacilli may be found. Of the former, the most numerous are large cocci, lying either irregularly or in small chain-form,—the *micrococcus ureæ*. This coccus, to a great degree, causes ammonical decomposition of the urine, the urea being transformed by it into carbonate of ammonium. In urines containing pus-corpuscles in large numbers, both *staphylococci* and *streptococci pyogenes*, the former being small cocci grouped in variously sized, irregular bunches, and the latter in longer or shorter chains, will also be seen. Besides these, the so-called *zoöglæa* groups of cocci—cocci arranged in more or less regular

masses—enveloped in a colorless, gelatinous capsule, may also be found, as well as large cocci, the *sarcinæ*, which are united into packets resembling corded bales of cotton, and are usually smaller than the sarcinæ found in sputa. Staphylococci and streptococci pyogenes are pathogenic, and may be found in any inflammatory condition.

Bacilli are usually present in varying numbers with the cocci, and are of different sizes, some of the small ones occasionally lying in twos, being formerly called *bacterium termo*, one of the varieties of putrefactive bacilli which cause ammoniacal decomposition of urine. Others, among them the *bacillus*, or *bacterium ureæ*, are larger, and there are still others larger than the latter, among which the *bacillus subtilis*, or hay bacillus, is common.

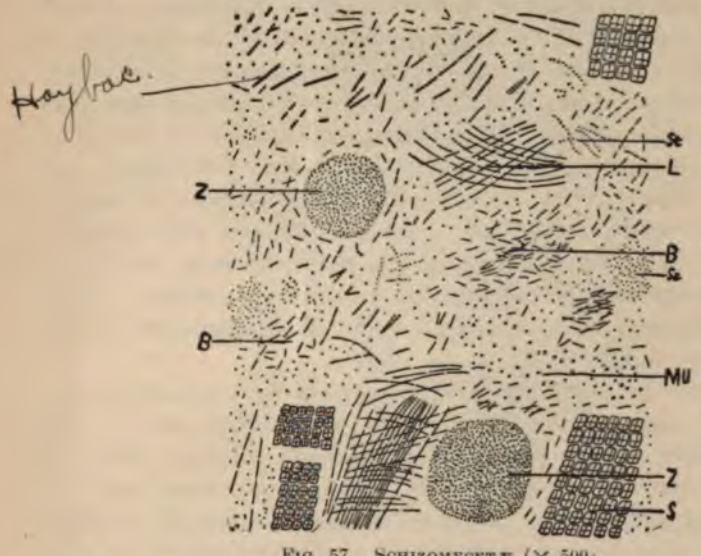

FIG. 57. SCHIZOMYCETÆ (× 500).

B, bacilli; St, streptococci; Sa, staphylococci; L, leptothrix; MU, micrococcus ureæ; Z, zoöglœa; S, sarcinæ.

These bacilli are found to have a varying amount of motion, some being very active, others only slightly movable, and some without motion.

Besides the single bacilli, the urine not infrequently contains threads, composed of individual rods,—the leptothrix threads,—which may be quite abundant. There are cases of chronic cystitis, in which the urine, when voided, contains leptothrix threads in large numbers, and in which the cystitis seems to be

caused by the leptothrix; these threads may lie upon as well as between the epithelia. In such cases whitish masses of small size are found in the freshly voided, cloudy urine, and when examined under the microscope are seen to consist of conglomerations of bladder epithelia with many leptothrix threads. Cases of this kind may last for many years, and frequently recur in spite of all local treatment; such a case might be termed *Mycosis leptothricia cystidis*.

PATHOGENIC SCHIZOMYCETÆ.—Among the pathogenic bacteria, the most important are undoubtedly the *gonococci* and *tubercle bacilli*, which are not infrequently found in urine, and for which careful search must, when necessary, be made. For the detection of these, it will always be necessary to color the specimens, and the mode of procedure is the following: Select the thickest portion of the urinary sediment or the threads, if any are present, as will be the case in every chronic gonorrhœa, and by means of a sterilized needle spread carefully over perfectly clean cover-glasses, taking never less than four, but preferably six or more. Allow the glasses to dry thoroughly, and draw them through the flame of an alcohol lamp or a Bunsen burner in a moderately quick manner, specimen side upward, three times, partly to fix the specimen upon the cover-glass, and partly to coagulate the albuminous substances present. Then color the specimen with an aniline color, either fuchsine, methylene blue, or gentian violet.

Gonococci.—In searching for gonococci in the urine, the cover-glasses are best colored, for a few seconds to one or two minutes, either with a plain watery fuchsine solution, made by taking one part of a concentrated alcoholic fuchsine solution (one part of fuchsine in substance to four or five of absolute alcohol) to eight, ten, or twelve parts of distilled water; or with a methylene blue solution—twelve or fifteen drops of a concentrated alcoholic solution to one ounce of water, to which one drop of a 5 per cent caustic potash solution has been added. Either one of these solutions, if carefully made, will keep a long time, and is always ready for use.

After having passed the cover-glasses through the flame, as just described, a small amount of the coloring solution is dropped upon the specimen and allowed to remain for from a few seconds to a minute or two, the former being sufficient when fuchsine is used, the latter being necessary when methylene blue

is employed. After coloring, the cover-glass is rinsed in water, the lower surface dried, and the specimen either at once mounted upon a slide and examined in water, or dried and mounted in a drop of Canada balsam.

Although the gonococci can be seen with a power of 500 diameters, it will always be better to use a power of at least 700 or 800 diameters and an Abbé condensor. In specimens so prepared, the gonococci, as well as the nuclei of the pus-corpuscles and epithelia, are colored. The pus-corpuscles will be seen to contain one or more nuclei.

In cases of acute gonorrhœa (see Fig. 58) the gonococci, or

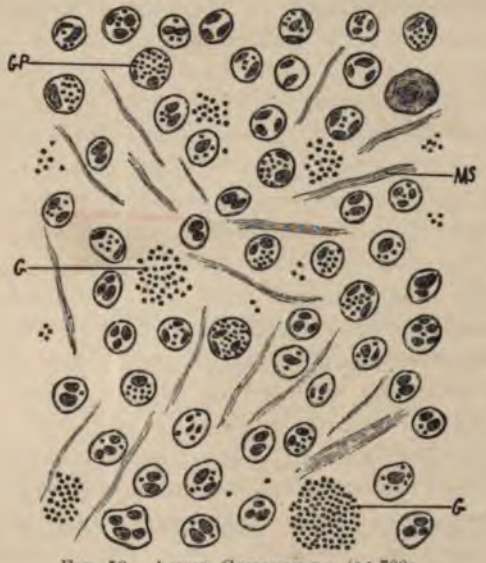

FIG. 58. ACUTE GONORRHŒA (× 700).

G, groups of gonococci ; G P, pus-corpuscle, containing gonococci ; M S, mucus-thread.

micrococci gonorrhœæ, are found in large numbers in the urine, not as numerous as in the gonorrhœal pus taken directly from the orifice of the urethra, but still very abundant. They are seen both in the pus-corpuscles and lying free in variously sized groups. The pus-corpuscles are numerous and mucus-threads in small numbers are always present. Urethral epithelia are also usually found, and may contain groups of gonococci.

Gonococci were first discovered by Neisser in the year 1879, and cultivated by Bumm in 1885. They are, as a rule, found in twos, either singly or in groups, with the adjacent surfaces

flattened and separated by a colorless interspace, giving the so-called biscuit shape. The more or less regular groups of *diplococci* are found either entirely within the pus-corpuscles or epithelia, or lying entirely free, but never half-way within and half-way free, though large groups, completely filling the pus-corpuscles, may slightly overlap the periphery. Again, no matter how completely the pus-corpuscles are filled with them, the nucleus or nuclei will always remain free, though here, again, individual cocci may be found upon the periphery of the nucleus. These features, though perhaps not absolutely characteristic, are sufficiently so for all practical purposes.

If any doubt remains about their character, a few specimens should be colored with a gentian violet solution, either a 1 per cent aqueous solution (gentian violet 1 part, distilled water 99 parts), or an aniline water solution, made by adding 5 parts of a concentrated alcoholic solution to 100 parts of aniline water (aniline oil 1 part, distilled water 20 parts, and filter) for a few minutes and subjected to Gram's solution (pure iodine 1 part, iodide of potash 2 parts, and distilled water 300 parts) for one or two minutes. The specimens are now washed in alcohol, then rinsed in water and recolored with a 1 or 2 per cent vesuvin solution (vesuvin 1 or 2 parts, distilled water 99 or 98 parts) for a few minutes, again rinsed in water, and either examined in water or dried and mounted in Canada balsam.

When subjected to this method, the gonococci will have lost their original violet stain and have taken up the vesuvin, being, therefore, colored brown. This method at once differentiates them from the staphylococci, which retain their violet color. If all the features enumerated, especially their characteristic grouping within the pus-corpuscles, and the loss of their violet color by the last-named method, are present, no doubt whatever will exist as to the character of the cocci.

In acute cases of gonorrhœa, the search for gonococci is very easy; but this becomes a more difficult matter in the chronic cases, where only a small number of gleet-threads are found in the urine. Frequently it is of the utmost importance to determine the presence or absence of gonococci in such cases, and the gleet-threads are subjected to the methods just described, and carefully examined. In this work it is never advisable to depend upon a power of 500 diameters, but higher powers, even a homogeneous immersion lens, should be used, and a large number of

specimens carefully examined. The features found in such a gleet-thread, containing gonococci, are shown in Fig. 59.

Pus-corpuscles are never so abundant in these cases as in the acute, and may even be quite scanty, but mucus-threads as well as corpuscles are numerous; epithelia from the urethra, and usually from the prostate gland, will also be seen. The gonococci are

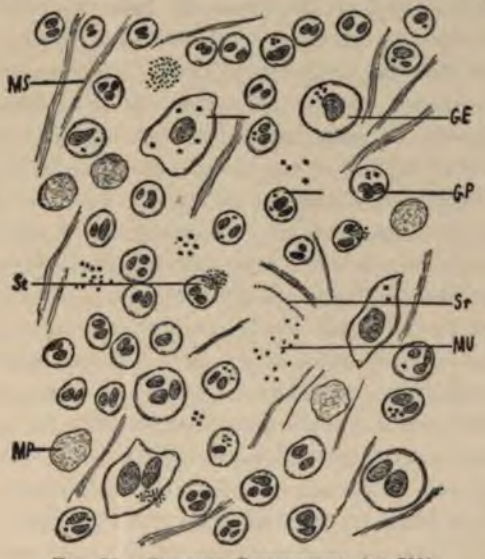

FIG. 59. CHRONIC GONORRHŒA (× 700).

GP, pus-corpuscles containing gonococci; GE, epithelium from the prostate gland containing gonococci; St, pus-corpuscles, containing staphylococci pyogenes; Sr, streptococci pyogenes; MU, micrococcus ureæ; MS, mucus-threads; MP, mucus-corpuscle.

(Gleet " 1959

always found in smaller numbers, but only singly or in small groups, and the cocci seen should never be diagnosed as such, unless some are found within the pus-corpuscles. Besides gonococci, such threads will always contain irregular groups of staphylococci; these may be either free or in groups, lying partly within pus-corpuscles and partly outside. In some cases, streptococci, usually in rather small chains, are also present, as well as the micrococcus ureæ in chains or irregular small groups.

Other Cocci.—Besides gonococci, other pyogenic cocci, both staphylococci pyogenes and streptococci pyogenes, are found in urine, but as may be expected, only wherever there are large numbers of pus-corpuscles; they, therefore, have little practical significance. The staphylococci are the staphylococcus pyogenes aureus, albus, and citreus, which can only be differentiated by

culture methods. Besides the streptococcus pyogenes, a streptococcus, which can not be distinguished from it, but has been described by Fehleisen as being the cause of erysipelas, may be found in all cases of erysipelas in which a nephritis is at the same time present. Micrococci have also been seen in the urine in septic processes, as well as in endocarditis.

Tubercle bacilli.—The presence of tubercle bacilli in moderate numbers in the urine is always a symptom of tuberculosis somewhere in the genito-urinary tract. Its exact location can easily be determined by the characteristic epithelia. As a rule, they will be found in larger numbers only when an ulceration has taken place; and whenever the diagnosis of an ulceration can be made from the different features found in the urine, together with an impaired or broken down constitution, it will be best to examine for tubercle bacilli, even though distinct clinical symptoms of a tubercular process have not as yet developed.

The search for tubercle bacilli in the urine is by no means an easy one, and many drops may have to be examined before arriving at a definite conclusion.. The appearance of the urine is no criterion, since bacilli may be present in small numbers in rather clear urine, though as a rule, it will be more or less turbid. They can be found in either an acid, neutral, or alkaline urine, though a large number of salts renders their detection still more difficult. The thickest portion of the sediment only should be used for the preparation of cover-glass specimens, and here the use of the centrifuge offers an undoubted advantage, the bacilli being more easily discovered in a centrifuged than in a non-centrifuged urine, since the centrifuge throws down all bacilli in larger numbers than is the case with urine which has been allowed to settle for a number of hours.

The methods employed for detecting tubercle bacilli are numerous; but the best are the Koch-Ehrlich-Weigert aniline water and the Ziehl-Neelsen carbolic acid water methods. Whether fuchsine or gentian violet is used with the former method is perfectly immaterial. An aniline water fuchsine solution is made by adding enough of a concentrated alcoholic fuchsine solution to aniline water until saturation takes place; that is, until a distinct film appears at the top of the solution; this will usually be one part of the alcoholic solution to six, eight, or even ten parts of aniline water. The aniline water is prepared by thoroughly mixing one part of aniline oil with 20 parts of distilled water,

and filtering through a double layer of filter-paper. This solution must be perfectly clear. The cover-glasses, which, when dried, have been passed through the flame, are now dropped upon the solution, specimen side downward, so as to float, if possible, and allowed to remain in it for twelve hours, if kept at the temperature of the room, or forty minutes if the solution is kept warm. It is not advisable to heat the cover-glasses over the flame for a few minutes after having dropped the coloring solution upon them, as such specimens are usually not as clear as they should be.

It has been shown by Koch that while tubercle bacilli take on the coloring matter slowly, they are then not readily decolorized, in contradistinction to other bacteria, which will quickly lose their color when subjected to the action of strong acids. The cover-glasses, after being colored, are, therefore, placed into a strong acid solution, preferably a 25 per cent nitric acid, for a few seconds or half a minute, and are then thoroughly washed in a 60 per cent solution of alcohol until all color has disappeared, rinsed in absolute alcohol and in water, and may either be examined at once, or, better, are recolored with methylene blue, again rinsed in water and examined in water or Canada balsam. The tubercle bacilli, if any are present, will now be seen in the form of red rods, while all other features in the specimen are colored blue. Instead of aniline fuchsine, aniline gentian violet can be used, and vesuvin employed as a recoloring agent. Muriatic or sulphuric acid may be used instead of nitric acid.

A specimen of tuberculosis of the kidney, colored in this manner, is shown in Fig. 60. The features which can easily be recognized are tubercle bacilli in moderate numbers, pus-corpuscles, epithelia from the convoluted tubules of the kidney, epithelia from the pelvis of the kidney, mucus-threads, mucus-corpuscles, and various cocci.

Although specimens prepared with an aniline water solution give excellent results, there is one objection to this method, which is that the solution does not keep, and has to be prepared fresh every week. Many bacteriologists, therefore, prefer to use Ziehl-Neelsen's carbolic acid fuchsine method. The solution is prepared by taking 90 parts of a 5 per cent carbolic acid solution, 10 parts of alcohol, and 1 part of fuchsine in substance. This is undoubtedly the simpler method, and gives good results as long as the solution is not too old. With it the specimens need not be colored longer than one or two hours, when kept at the tempera-

ture of the room, or twenty minutes when dropped in a warm solution. The decolorizing and recoloring processes are exactly the same as with the Koch-Ehrlich-Weigert method.

Since examination for tubercle bacilli in urine is not an easy matter, it is invariably best to use those methods which will yield uniformly good results, and not to hasten the process of coloring. With the two methods just described, the tubercle bacilli can

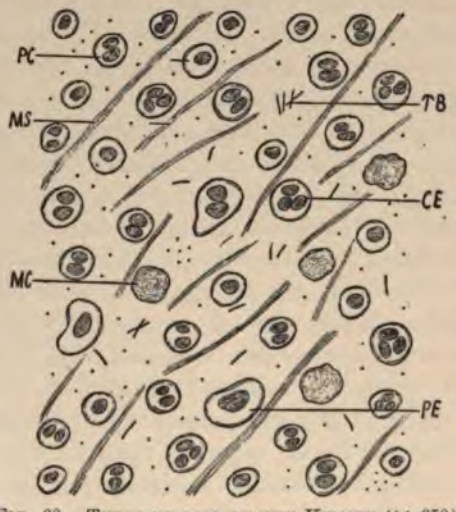

FIG. 60. TUBERCULOSIS OF THE KIDNEY (× 650).

TB, tubercle bacilli ; PC, pus-corpuscle ; CE, epithelium from convoluted tubules of kidney ; PE, epithelium from pelvis of kidney ; MS, mucus-threads ; MC, mucus-corpuscle.

always be detected if present, though they may be very scanty, and found only after a long and patient search.

Typhoid bacilli.—Among the other pathogenic bacilli found in urine, the *typhoid bacilli* have been discovered in large numbers in cases of typhoid fever, though never at the commencement of the disease, and they are not, therefore, of much practical value for the diagnosis. Poniklo, in the year 1892, was the first to call attention to the presence of typhoid bacilli in the urine, and since then the bacilli have been found by different observers. In most cases described, the evidences of a more or less pronounced nephritis or of a hæmorrhage were also present. The bacilli may persist in the urine for weeks and even months, and may be extremely abundant.

Bacterium coli commune.—The *bacterium coli commune* is not infrequently present in urine, especially in pronounced in-

flammations, such as severe cystitis; it may be found in large numbers, and is mentioned by some writers as a common cause of cystitis. In the year 1895, Pluym and Laag described it as the sole cause of a urethritis which gave all the symptoms of a gonorrhœal infection, in which gonococci were entirely absent, but the bacterium coli commune was found in large numbers, lying mostly within the pus-corpuscles and epithelia.

Other bacilli have also been described as being present in various diseases of the genito-urinary tract, but they are of no diagnostic value.

Actinomyces.—The fungus known as *actinomyces* (see Fig. 61), is of rare occurrence in the urine, but is undoubtedly found in actinomycosis of the internal organs, where the disease affects the genito-urinary tract. The classification of this fungus has long

FIG. 61. ACTINOMYCES (× 500).

been undecided, though later researches place it among the fission-fungi.

The fungus consists of variously sized conglomerations of highly refractive, irregular, club-shaped masses. The club-shaped, cylindrical, or pear-shaped masses terminate toward the center in a point or fibrilla, which loses itself in a mass of granules, amidst other similar fibrillæ. The individual club-shaped elements greatly vary in length, but all terminate in the center.

The urine from which the accompanying drawing was made

was turbid when passed, and gave all the macroscopical evidences of a chronic cystitis. It contained a few small granular masses which proved to be actinomyces. The features present under the microscope were numerous, and conclusively showed a chronic ulcerative process in the bladder; there were pus-corpuscles in large numbers; epithelia from the bladder, especially cuboidal and columnar; numerous connective-tissue shreds; fat-granules and -globules; large zoöglœa masses; mucus-threads and -corpuscles, and the actinomyces fungus, which was perfectly characteristic, so that the diagnosis of a chronic ulceration of the bladder, due to actinomyces, could easily be made. The reaction of the urine was alkaline.

II. ANIMAL PARASITES OR ENTOZOA

Trichomonas Vaginalis (see Fig. 62).—Of all the animal parasites, the most common is the *trichomonas vaginalis*, which belongs to the class of infusoria. It occurs in the urine of

FIG. 62. TRICHOMONAS VAGINALIS (× 500).

females, being a frequent but perfectly harmless inhabitant of the mucosa of the vagina in cases of leucorrhœa. Although it has no pathological significance, its occurrence and shapes must be known, since it otherwise might be mistaken for different formations, especially when small.

Trichomonas is of an oval or somewhat irregular form, and usually has a tail-like extremity. This extremity, mostly of the same size as the body or a little longer, may occasionally be three or four times that size, of considerable thickness, and striated. It may, however, be nothing but a small filament

FIG. 63. PORTIONS OF ECHINOCOCCUS (× 400).

like a flagellum. In the interior of the body one, two, or more small formations, similar to nuclei, may be seen. In many cases one or more cilia are given off from one extremity or side.

Echinococci (see Fig. 63).—These entozoa, although rare, do occasionally occur in the urine, and may either have developed directly in the urinary organs, or have ruptured from some neighboring organ. The characteristic parts of the *echinococci*, found in the urine, are the hooklets as well as portions of the membrane; scolices may also be found.

The echinococci cysts, as such, will never be seen in the urine, and in a suspected case it may become quite difficult to find the characteristic portions. The scolices are small, usually round, and supplied with a wreath of hooklets. The individual hooklets do not vary in size to a great degree, and their shapes, although differing somewhat, are more or less identical. Parts of the membrane which have a concentric striation may at

times be present. In the specimen from which the illustration was taken, the different portions here shown could only be found after patient search, but were characteristic.

In all cases in which parts of the echinococci are found in the urine, evidences of a hæmorrhage or an ulceration, or both, will be present. As a rule, red blood-corpuscles are numerous, together with epithelia and connective-tissue shreds from the organ in which the cysts are located. Pus-corpuscles are usually abundant. When the echinococci have directly developed in the urinary organs, the kidney is the general location, and epithelia from both the convoluted and straight collecting tubules are present.

Distoma Hæmatobium (see Fig. 64).—The parasite, *distoma*

FIG. 64. OVA OF DISTOMA HÆMATOBIUM (× 600).

hæmatobium, or *Bilharzia hæmatobia*, so called from Bilharz, who first described it, has probably never been found in the urine, but its eggs do occur in some cases. It is common in hot climates, especially in Egypt, and is found in the portal vein and its branches, the splenic and mesenteric veins, as well as in the venous plexuses of the rectum and urinary bladder.

In our climate distoma hæmatobium is rarely found, but does occur. A case of this kind was recently described by Brooks and Sondern, who found the eggs in the urine in considerable numbers. The illustration was taken from this urine, and in every drop examined a dozen or more of the ova were

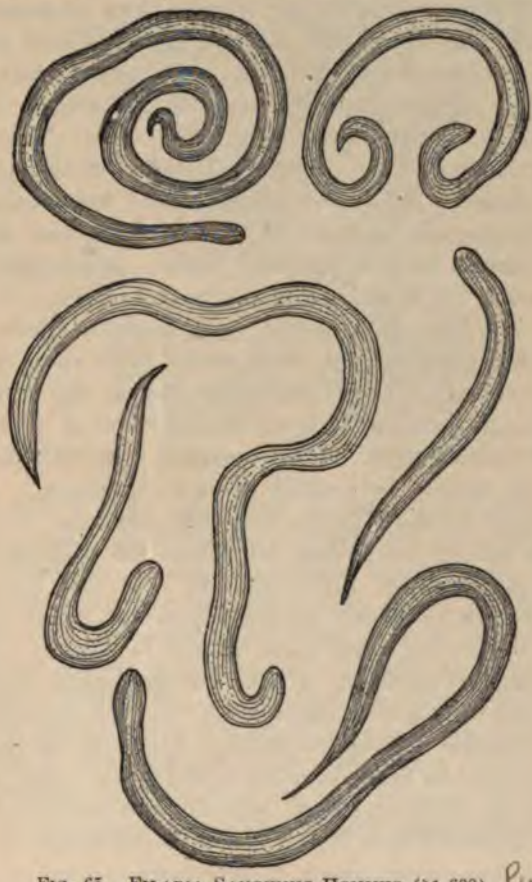

FIG. 65. FILARIA SANGUINIS HOMINIS (× 600). Pure white urine

present. They have an oval or flask-like shape, are large and taper considerably at one extremity, the other being rounded. They consist of a moderately thick, highly refractive capsule, are coarsely granular, and contain quite a number of small, roundish, granular bodies within a membranous formation.

When these ova are found in the urine, blood-corpuscles, pus-corpuscles, and epithelia, usually from the bladder, are seen, show-

ing a hæmorrhage or inflammation of the bladder. In most cases fat-globules and -granules are also present in considerable numbers. The parasites may invade any portion of the urinary tract, especially the ureters and pelves.

Filaria Sanguinis Hominis (see Fig. 65).—This parasite is also of rare occurrence in our climate, but common in other climates, as in the West India Islands, Egypt, China, and Japan. It seems to be transferred to human beings through mosquito bites, and may be extremely abundant in the blood; in urine it may be found in varying numbers in such cases. It consists of a cylindrically shaped body, a short, rounded head, and a long, thread-like, pointed tail. It is granular and frequently striated.

When the parasite appears in the urine, it may either cause severe hæmaturia or the condition known as chyluria, or more frequently both. It is claimed that it may be present in perfectly clear urine, but this must be very rare, since, as a rule, the urine presents a milky appearance when voided, and upon examination is found to contain a large amount of fat, in the form of small globules and granules, as well as the evidence of a more or less pronounced hæmorrhage. Pus-corpuscles, as well as different epithelia, will usually be present in small numbers.

When such a milky urine, denoting chyluria, is examined, filaria must always be looked for, since the parasite is almost invariably the cause of this condition. It may be present in large numbers in the urine, so that there will be no difficulty in finding it; but on the other hand, it may be scanty. In examining for filaria, it is advisable to take the first urine voided in the morning, since it is a well known fact that the parasite is active at night, or rather during the resting hours of the patient, and can then be found in large numbers in the blood, while it is quiescent during the working hours, and can not be found.

Ascaris Lumbricoides (see Fig. 66).—Although in rare instances only, the round worm, *ascaris lumbricoides*, of such common occurrence in the intestinal tract of children, may be found in the urine, having passed into the bladder through the urethra. Portions of the parasite and a number of ova will then be present in the urine.

The urine from which the illustration was taken gave all the features of a severe acute catarrhal cystitis. It contained a small number of minute particles, which proved to be the ova; also a part of the body of an ascaris. The ova, of a yellowish

brown color, are round formations, inclosed in a thin, irregular capsule and a somewhat thicker membrane; the interior is coarsely granular and contains a nucleus. The parasite itself is of considerable size, has a cylindrical body, a narrower, tail-like

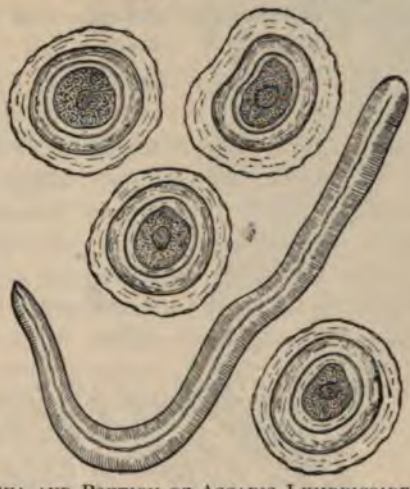

FIG. 66. OVA AND PORTION OF ASCARIS LUMBRICOIDES (× 500).

extremity, and a head consisting of three papillæform nodules; it is only found in the urine in very rare instances.

Other Parasites.—Other parasites which may possibly be found in the urine are the *Strongylus gigas*, *Oxyuris vermicularis*, and the *Cercomonas urinarius*. The strongylus gigas resembles the ascaris lumbricoides, although it is much larger, and its head contains six papillæform nodules instead of three. The oxyuris vermicularis is a small, thread-like formation, and the cercomonas urinarius a small infusorium, which consists of an oval, granular body, and contains a number of cilia. These parasites are extremely rare and of no practical importance.

FIG. 70. WOOL-FIBERS (× 500).

the cuticle; their structure is faintly striated. Hairs of different animals have different forms, and we may observe the central medullary canal and a varying amount of pigment.

Any of these fibers may be found dyed in different colors, which is sometimes quite misleading.

Human Hairs. — Human hairs are also not infrequently found in the urine, and may be known by the flat epidermal scales, firmly attached to each other, which form the main mass of the hair, and by the varying amount of pigment.

Feather (see Fig. 71).—Feather may appear in the shape of branching formations, which have their origin at the quill, and run in different directions, or in single barbules. The quill is striated. The barbules are composed of different sized links, and gradually taper toward the ends, which are whip-like.

Scales from Moth (see Fig. 72).—Scales from the wings of insects, such as moths, may also be found. They are more or less delicate, serrated plates with a stem-like projection, and vary considerably in length and breadth.

Starch-Globules (see Fig. 73).—Starch-globules are frequently seen in the

FIG. 71. FEATHER (× 400).

urine. They are more commonly found in the urine of females, starch powders being extensively used for dusting purposes, but individual globules from the underwear are also seen. They are oval or round, highly refractive, and vary greatly in size, with a more or less central hilum or umbilicus, around which are concentric striations. The hilum may be either round, oval, or irregular, at times quite large, at times small, and occasionally appearing as if split.

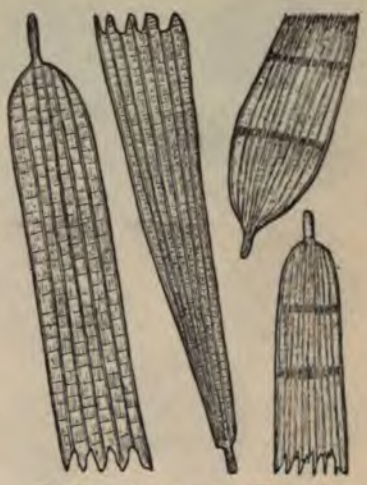

FIG 72. SCALES FROM WINGS OF MOTH (× 500).

The different varieties of starch, although having the same characteristics, vary in shape as well as in size. The three most frequently found in the urine are rice-starch, corn-starch, and wheat-starch. Rice-starch always appears in the form of oval or oblong, quite regular globules of medium size. Corn-starch is smaller, irregular, at times almost hexagonal, and contains an irregular hilum. Wheat-starch consists of large globules, as well as of small, irregular formations, in which latter the hilum may be entirely absent, or is present only in the form of a dot.

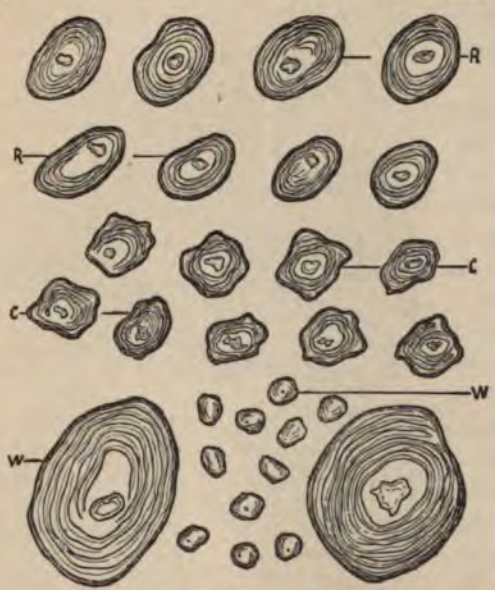

FIG. 73. STARCH-GLOBULES (× 500).
R, Rice-starch ; C, corn-starch ; W, wheat-starch.

Lycopodium (see Fig. 74).— Lycopodium, somewhat similar to starch, and also considerably used for dusting purposes, con-

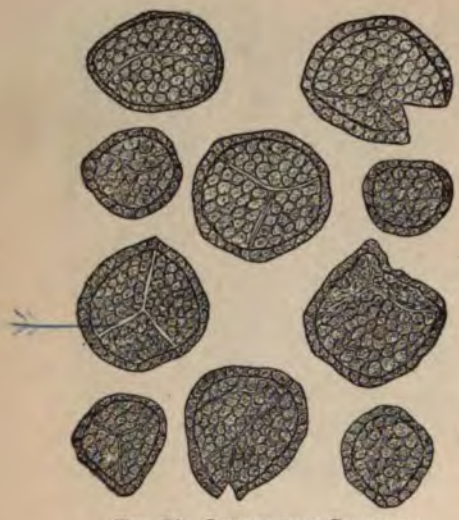

FIG. 74. LYCOPODIUM-GLOBULES (× 500).

sists of globular formations of different sizes, with a distinct shell, and studded with peculiar thorny projections. Many globules seen in urine are partially broken, and in some an irregular or triangular division is noticeable.

Cellulose (see Fig. 75).—Cellulose occurs in the urine in a variety of forms, sometimes in small, sometimes in large masses. It varies considerably, according to the plant or portion of plant from which it is derived, and may be brown, pale yellow, or practically colorless. It may be seen in the urine in the form of a framework, sometimes angular, the individual cells being connected with each other by the intercellular substance. In the interior of many, though not in all cells, a nucleus, usually somewhat irregular, will be present, and both the cells and the nucleus are granular.

Instead of the irregular angular cells, perfectly regular, either rectangular or square cells, with large, regular, oblong nuclei, may be seen, and these may also be found singly or in masses.

Cork (see Fig. 76).—A common variety of cellulose seen in urine is cork. This occurs either in single cells or smaller conglomerations, and has a yellowish brown or reddish brown color. The individual cells are irregular and greatly vary in size. They are either perfectly

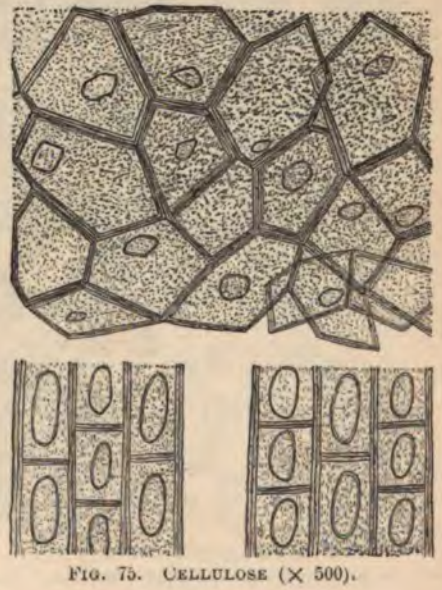

FIG. 75. CELLULOSE (× 500).

homogeneous or contain a small number of indistinct granules. At times, many of these cells will be found closely packed together. When the cells are thin, they may possibly be mistaken for epidermal scales, but their color is always sufficient to differentiate them from the latter.

FIG. 76. CORK (× 500).

Oil-Globules and Air-Bubbles (see Fig. 77).—Extraneous fat- or oil-globules are of common occurrence in urine. They may be very large or extremely small, and are either perfectly round or irregular. They have a high refraction, and can frequently be differentiated by their yellowish color. The smallest globules might perhaps be mistaken for fat-globules voided with the urine, but are almost invariably associated with the larger, more irregular, yellowish globules.

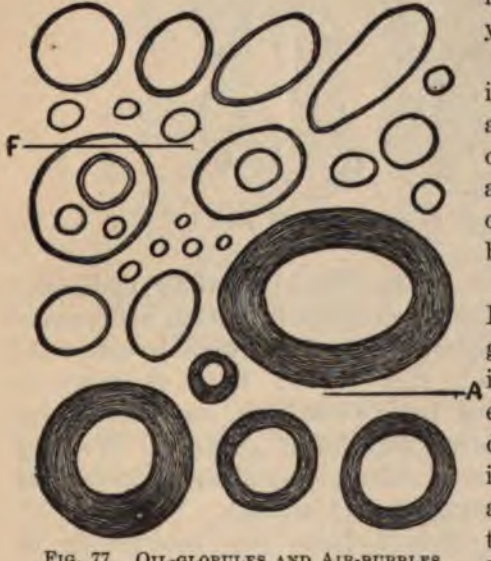

FIG. 77. OIL-GLOPULES AND AIR-BUBBLES (× 500).
F, fat- or oil-globules; A, air-bubbles.

Air-bubbles also vary in size to a great degree, and may be either round or irregular; they have a sharply defined, double contour and a blue or bluish black refraction.

Flaws in Glass (see Fig. 78).—Flaws in the glass, as well as scratches in the cover-glass, may easily lead to a mistaken diagnosis. The flaws are irregular in size and shape, and frequently resemble the wings of a butterfly. They have a faint blue refraction and are usually

pale. A little care is sufficient to diagnose them, and if their identity is not plain, a change of the glass will suffice to note their character.

Rust-particles in both the cover-glasses and slides also occur, and are larger or smaller, dark or rust-brown irregular masses, which must not be mistaken for coloring matter in the urine. The smaller masses somewhat resemble hæmatoidin crystals, but are always more irregular.

Vegetable Matter (see Fig. 79).—Vegetable matter of different forms may be found in the urine as an admixture from

FIG. 78. FLAWS IN THE GLASS (× 500).

the fæces. Different plants, which remain partially undigested and may be passed with the fæces in small masses, will present a variety of features. Spiral fibers from the air-vessels of plants are quite numerous in such masses. Hairs of plants, as well as vegetable-fibers, the latter resembling connective-tissue shreds, will be found, besides particles of cellulose. We may furthermore see starch- and chlorophyl-globules, masses of spores, fat-globules and margaric acid needles.

Fæces (see Fig. 80).—Normal fæces may occasionally be found mixed with urine, and their constituents must be known. If they are present, and their accidental admixture can be

excluded, the diagnosis of a fistula can be made. Although their features vary greatly, depending upon the food, the most common with a mixed diet are the following:

Partly digested muscle-fibers of a yellowish or brown color

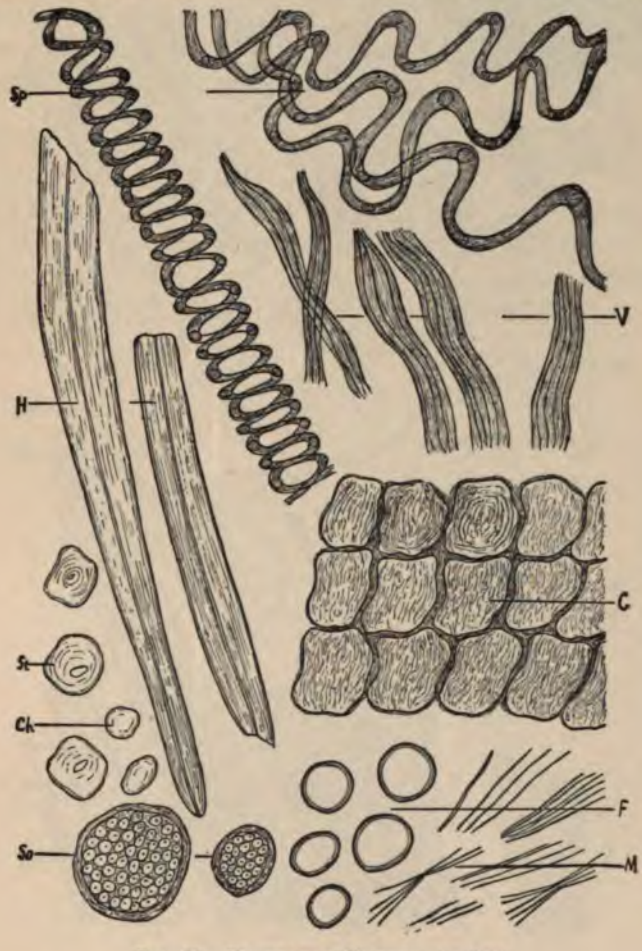

FIG. 79. VEGETABLE MATTER (× 500).

Sp, spiral fibers from air-vessels of plants; V, vegetable-fibers; H, hairs of plants; C, cellulose; St, starch-globule; Ch, chlorophyl-globule; F, fat-globules; M, margaric acid needles; So, spores.

are almost constantly seen; in many the striations will be plainly visible, while in others no structure can be made out. Connective-tissue shreds from the meat diet, in small numbers, are also present. Spiral fibers, hairs of plants, and different

forms of cellulose are almost constant ingredients, as well as starch- and chlorophyl-globules, and fat in the form of globules and needles.

Mucus-threads and mucus-corpuscles are usually found in

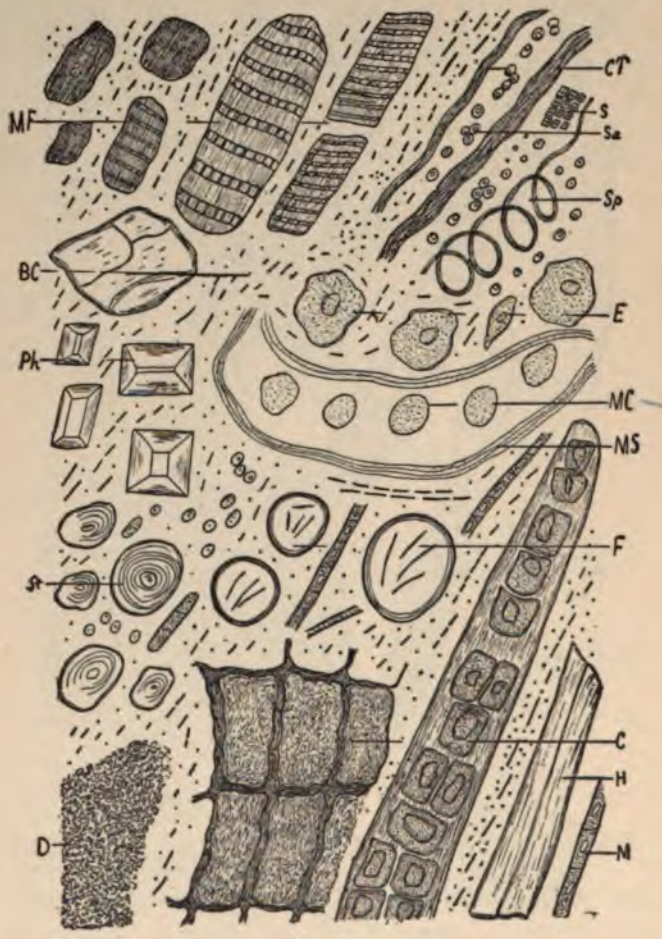

FIG. 80. NORMAL FÆCES (× 500).

MF, muscle-fibers; CT, connective-tissue shreds; Sp, spiral fiber; C, cellulose; H, hair of plant; MS, mucus-thread; MC, mucus-corpuscle; E, epithelia; Ph, triple phosphates; St, starch-globules; D, debris; M, mycelium; S, sarcina; Sa, saccharomyces; F, fat-globules containing margaric acid needles; BC, bacilli and cocci.

normal fæces, as well as different varieties of epithelia. The latter are mostly of the flat variety, derived from the mucous membrane of the anus, although a few columnar epithelia are

not rare. Crystals of various kinds, but most commonly triple phosphates, may be quite abundant. Different non-pathogenic bacteria, such as conidia and mycelia in small numbers (undoubtedly secondary products), saccharomyces, and large numbers of bacilli and cocci, may be found. Besides these features masses of debris, digested material, in smaller or larger conglomerations, will be seen.

The extraneous matters here enumerated as occurring in the urine are those which are more commonly found; but other features may be seen at one time or another. For instance, water-fungi of different varieties, although rare, are known to occur in urine. It will, however, be a comparatively easy matter to recognize most of the extraneous objects.

Part Three

MICROSCOPICAL URINARY DIAGNOSIS

Part Three

MICROSCOPICAL URINARY DIAGNOSIS

Although it has been customary, in arriving at a correct diagnosis of diseases of the genito-urinary tract, to consider the microscopical examination of the urine as only of secondary importance, and, in diagnosing the different inflammations of the kidney, to rely solely upon the presence of casts, a perusal of the previous pages will show that the microscope is not only of the utmost importance in all these affections, but is frequently the only means of arriving at correct conclusions as to the nature of the case.

It is a well known fact that in many cases in which a small amount of albumin is present in the urine, and in which the clinical symptoms seem to point to a nephritis, even if only slight, that diagnosis will not be made, because frequent examinations of the urine fail to reveal any tubular casts, and the physician is apt to rest satisfied with the diagnosis of "functional albuminuria;" yet a large number of not infrequently severe cases of nephritis exist which never show casts in the urine. In cirrhosis of the kidney, for instance, the presence of casts is extremely rare, and when they are present at all, are so scanty, in most cases, as to be entirely overlooked.

On the other hand, many cases of nephritis, often lasting for years, will give such ill-defined clinical symptoms that a kidney inflammation is rarely thought of; and the examination of the urine, if made at all, is done rapidly, and merely with the idea of satisfying oneself that casts are not present. Many of these cases will show only a trace of albumin in the commencement stage, and might not only be greatly benefited, but entirely cured, if a proper diagnosis were made soon enough. Such a diagnosis can always be made from a microscopical examination of the urine, even without the presence of casts, and the larger number of the mild cases never show casts in the urine at any time.

The diagnosis of an inflammation or other affection of the kidneys is undoubtedly the most important; but a microscopical examination of the urine may also be the only means of positively diagnosing the nature of a disease of the pelvis of the kidney, the bladder, and the prostate gland, as well as of clearing up a suspected case of inflammation of the seminal vesicles. In the female, an inflammation or ulceration of the vagina, the cervix uteri, and the mucosa of the uterus can often be positively identified from the examination of urine, without the necessity of an examination of the patient. It can thus easily be seen that the microscope plays an extremely important role in genito-urinary affections, either giving the first evidence of a disease, or helping to clear up a doubtful diagnosis.

In the following pages only those affections will be considered which can be positively diagnosed from a microscopical examination of the urine.

CHAPTER XIV

DISEASES OF THE KIDNEY AND PELVIS

I. *INFLAMMATIONS OF THE KIDNEY AND PELVIS*

Classification.—There are probably no diseases in which the opinions of pathologists differ so much, and in which the nomenclature is so varied, as in inflammations of the kidney, —nephritis. The result must necessarily be confusion. Such different terms as Bright's disease, interstitial, desquamative, exudative, parenchymatous, and diffuse nephritis are met with, and congestion, hyperæmia, glomerulitis, pyelo-nephritis, and amyloid disease are all looked upon as different affections. While some authors use the term Bright's disease as indicating all the different varieties of nephritis, others call diffuse nephritis *Morbus Brightii;* others, parenchymatous nephritis; and still others, combinations of different varieties.

One classification* gives no less than seven different varieties of Bright's disease: (1) Congestion of the kidney; (2) acute parenchymatous nephritis; (3) chronic parenchymatous nephritis; (4) acute diffuse nephritis; (5) chronic diffuse nephritis; (6) acute interstitial nephritis; (7) chronic interstitial nephritis. Besides these, this classification gives suppurative nephritis and pyelo-nephritis separately.

Another classification† of Bright's disease is the following: (*a*) Acute nephritis (acute Morbus Brightii), in which acute hæmorrhagic nephritis and acute glomerulo-nephritis are included; (*b*) chronic nephritis (chronic Morbus Brightii), which is again divided into four varieties — (1) large white kidney (inflammatory fatty kidney), (2) large red kidney (chronic hæmorrhagic nephritis); (3) secondary cirrhosis of the kidney, and (4) contraction of the kidney (cirrhosis, granular atrophy of the kidney). Besides these, this author speaks of interstitial

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* Delafield and Prudden, "A Handbook of Pathological Anatomy and Histology." New York, 1885.

† Birch-Hirschfeld, "Lehrbuch der Pathologischen Anatomie." Leipzig, 1887.

suppurative nephritis (pyelo-nephritis and embolic suppurative nephritis), as well as of fatty, calcareous, and amyloid degeneration of the kidney.

Without going any further into the different classifications, which no two authors give alike, the latest classification* only will be mentioned: This simply gives the varieties as acute and chronic nephritis, dividing the latter into chronic parenchymatous and chronic interstitial nephritis (cirrhosis, granular atrophy of the kidney).

It is, therefore, not at all surprising that the pathology of nephritis is considered to be one of the most complicated chapters in pathology; yet it will become perfectly plain, and the features found in urine easily explained, if we consider the anatomical structure of the kidney, which is that of a compound tubular gland, consisting of epithelial and connective tissue; the latter alone carries the blood-vessels, the contents of which, the blood, furnishes the material from which the epithelia produce the secretions.

Experiments have frequently been made to show that pathological conditions of the epithelia can exist independently of the underlying connective tissue carrying the blood-vessels. It has been asserted that in acute cases of poisoning, such as with cantharides and phosphorus, the pathological process is confined to the kidney epithelia alone. Other experiments have, however, conclusively proved that an independent pathological condition of the epithelia does not exist. The poison, before it reaches the epithelia, must pass the walls of the blood-vessels and the connective tissue lying between the epithelia and the walls of the blood-vessels, and has an irritating influence upon the latter. In this connective tissue, changes are always found, though they may be confined to serous transudation, sufficient to show that the epithelium can not become diseased primarily and independently of the surrounding connective tissue.

It is, therefore, plain that the classification by Virchow, of inflammations into *interstitial*, that is, confined to the connective tissue, and *parenchymatous*, confined to the epithelia, is not strictly correct. Every inflammation is primarily an interstitial one, and every parenchymatous inflammation must also at the same time be an interstitial one. It is perfectly true, however,

* Hilbert, in "Bibliothek der gesammten medicinischen Wissenschaften." Vienna, 1898.

that the pathological changes may be more pronounced in the epithelia than in the connective tissue; the latter may not pass beyond the stage of serous transudation, while in the former coarse granulation, so-called cloudy swelling, may occur; in cases of phosphorus poisoning fatty degeneration may be present.

The character of an inflammation depends to a great degree upon the nature of its exudate, which may be either serous, fibrinous, or albuminous. In former years inflammations of mucous membranes were divided into *catarrhal* and *croupous;* in the first a serous or sero-mucous exudate is formed, while in the second it is fibrinous in its character. These names, though not of great significance, are perhaps preferable to Virchow's terms, interstitial, desquamative, and parenchymatous, which, as has been shown, can not be carried out. An inflammation in an organ composed of connective and epithelial tissue will affect all its component parts to a greater or less degree, so that it will be diffuse to a certain extent at the outset. The difference exists only in the degree in which the different tissues are affected. We may, if we wish, speak of an interstitial inflammation when the pathological changes are more pronounced in the connective tissue, and of a parenchymatons inflammation when they are more pronounced in the epithelia.

As every inflammation of the kidney is bound to be more or less diffuse in its character, and the term Bright's disease conveys no meaning as to the character of the inflammation, which may run an acute, subacute, or chronic course, all cases of nephritis may best be divided in the following manner:

1. Catarrhal, interstitial, or desquamative nephritis.
   - (*a*) Acute.
   - (*b*) Subacute.
   - (*c*) Chronic, terminating in cirrhosis of the kidney.
2. Croupous or parenchymatous nephritis.
   - (*a*) Acute.
   - (*b*) Subacute.
   - (*c*) Chronic, terminating in atrophy of the kidney.
3. Suppurative nephritis or pyonephrosis.
   - (*a*) Acute.
   - (*b*) Chronic.

It is hardly possible to speak of a subacute abscess, since all such cases which have lasted for a number of weeks are properly chronic.

Congestion or hyperæmia of the kidney can not be considered as a separate affection, since it is either the first stage of a commencing inflammation, or a mere irritation, which can not be properly termed inflammatory as yet, but which sooner or later will undoubtedly develop into an inflammation.

Glomerulitis or glomerulo-nephritis, again, is not an independent inflammatory process, but only a symptom of one of the inflammations, since the glomeruli will always be attacked to a greater or less degree in every nephritis.

Fatty and waxy, or amyloid, degenerations of the kidney are always secondary products, due to a chronic inflammation, and part of such an inflammation.

Pathological Changes. — Let us now briefly consider the pathological changes which take place in these different inflammations of the kidney:

1. *Catarrhal Inflammation.* — In catarrhal or interstitial inflammation of a mild character, an œdematous swelling of the connective tissue is present, with swelling and granular cloudiness of the epithelial covering and subsequent desquamation of the epithelium. The blood-vessels show a more or less complete distension with blood-corpuscles, without apparent alteration in the structure of their walls. The œdematous swelling of the connective tissue, as well as the desquamation of the epithelia, are due to a serous exudation from the blood-vessels. On account of this serous exudation, the epithelia may become partly changed to mucus.

In severer cases an inflammatory infiltration of the connective tissue, which leads to hypertrophy, takes place, with proliferation, desquamation, and, finally, hyperplasia of the epithelium. In the highest degree of catarrhal inflammation, all the constituent parts of the kidney-tissue have disappeared in the inflammatory infiltration.

At the very commencement of an inflammation, the production of pus-corpuscles takes place, partly from the interstitial connective tissue and partly from the epithelium, which latter undoubtedly enters into the formation of pus-corpuscles to a great degree by division and endogenous cell-proliferation, as has been already shown by George Johnson, in the year 1852. As long as the newly formed corpuscles remain in connection with the tissue, we have inflammatory corpuscles; but as soon as they are torn from their connection with the tissue and

appear in the urine, the term pus-corpuscles must properly be applied to them.

When the disease has become chronic, the surface of the kidney is marked by irregular, shallow depressions, or by granulations, the capsule being adherent in most cases. The irregular depressions are due to retractions of newly formed connective tissue, which is formed at the expense of the uriniferous tubules. Chronic catarrhal or interstitial nephritis invariably leads to a shrinkage — *cirrhosis* — of the kidney. The whole kidney is considerably reduced in size and the irregularities on the surface are well marked. Both the cortical and medullary substances are much narrower than in the normal condition; this being more particularly the case in the cortex, of which, in advanced stages, only slight remnants are left, corresponding with the elevations of the surface. There is a partial destruction of tufts or glomeruli, tubules, and blood-vessels. The newly formed connective tissue is more or less regularly distributed throughout the kidney structure, the uriniferous tubules being in part transformed into connective tissue, while still retaining the outlines of their original configuration.

The obliteration of a number of the narrow tubules, including the ascending and descending branches, explains the clinical fact that persons affected with cirrhosis of the kidney void large quantities of urine almost destitute of salts. It is well known that the tuft excretes water only, which becomes thicker by the addition of the saline constituents excreted by the narrow tubules. It is in the narrow tubules that much of the watery part of the urine is restored to the thickened blood running in the neighboring capillaries. If the function of the tubules be much interfered with, the interchange between the liquid contents of the tubule and the solid constituents of the blood will not take place, and consequently the urine will be voided in about the same condition in which it was pressed into the capsule from the tuft. Numbers of the convoluted tubules perish also through the increased formation of connective tissue, while from others the epithelia are simply desquamated and appear in the urine.

2. *Croupous Inflammation.*—In croupous or parenchymatous inflammations, the surface becomes partially or completely denuded of its epithelium, a coagulated albuminous or fibrinous exudate is formed upon the surface, there is considerable hyperæmia of the blood-vessels, and a pronounced swelling and inflammatory

infiltration of the connective tissue. E. Wagner has shown that the epithelia enter very actively in the formation of the so-called croup membrane, and their protoplasm becomes almost completely destroyed in the fibrinous exudate.

In this variety of inflammation, the emigration of colorless blood-corpuscles is quite pronounced. Epithelia alone can not produce a croup membrane, but require the presence of an exudate from the blood, and the essential constituent of the croup membrane is the coagulable albuminoid body from the blood. We now have the formation of casts; the epithelia lining the tubules become saturated with the albuminous exudate, swell, grow pale, and finally, by coalescence of the epithelia thus degenerated, produce the mass called a tubular cast.

In chronic croupous nephritis, the kidney has an entirely different appearance from that found in chronic catarrhal nephritis and cirrhosis of the kidney. It is more frequently enlarged than diminished in size. The surface is often nodulated, and between the nodules are seen deep cicatricial retractions. These retractions are never found uniformly over the surface, and the capsule is adherent to the retractions. The cortical substance is absent in those parts corresponding with the retractions of the surface, while in other places the cortex may be unaltered or even increased in bulk. The pyramidal substance may be unchanged or may be diminished. In contradistinction to the more or less uniform shrinkage of the kidney, to which the name *cirrhotic* is given, the partial destruction of the tissue which occurs in chronic croupous nephritis may be termed *atrophy*, since in the most diseased portions only traces of the original kidney structure will be found.

In the depressed cicatricial portions of the cortical substance, a large amount of connective tissue, only scantily supplied with blood-vessels, is found. There is no regularity in the arrangement of the connective tissue, and only remnants of the former tubules are found, together with irregularly scattered sections of tubules, from which the epithelial lining has entirely disappeared. In the most pronounced cases, in addition to the atrophied portions, the large amount of newly formed connective tissue present in different places constitutes a regular hypertrophy.

Both fatty and waxy degeneration may be present in cirrhotic as well as in atrophied kidneys; but these changes are much more pronounced in the latter than in the former. In the so-called

large white kidney, the highest degree of fatty degeneration occurs as a secondary result of chronic croupous nephritis. Cystic degeneration may also be present in these cases, and is more pronounced in chronic croupous nephritis.

3. *Suppurative Inflammation.*—The most intense variety of inflammation of the kidney is the suppurative, which is similar to the formation of an abscess in other organs. For a long time this variety was considered to be a purely interstitial inflammation, since the opinion prevailed that pus-corpuscles could only be formed from connective-tissue cells. There is, however, no doubt, as previously stated, that the epithelia take an active part in the formation of pus. The blood-vessels soon become destroyed in this variety. Pus is disintegrated tissue, and in its formation all the elements of the tissue take part.

There may be either a number of small disseminated foci of suppuration or a large abscess, usually, if not invariably, caused by an invasion of pyogenic cocci. Besides the abscess, the kidney may present either the features of a catarrhal or of a croupous inflammation. When the abscesses become chronic, a dense connective-tissue capsule, the pyogenous membrane, may occasionally be found, and the pus becomes inspissated into a cheesy mass.

With these remarks upon the pathology of the different varieties of nephritis, we are ready to understand the features found in the urine of these cases. Although it is not possible to diagnose an acute, subacute, or chronic inflammation from the urine alone, in all cases of nephritis, it can undoubtedly be done from the different features seen in most cases, especially the more pronounced.

IRRITATION OF THE KIDNEY

From what has been said before, it is evident that the diagnosis of an inflammation can be made as soon as pus-corpuscles are found in the urine; without these, no such diagnosis is possible. In some cases, in which a trace of albumin is present, or no albumin whatever is found, an extremely small number of pus-corpuscles, perhaps one or two in every field of the microscope, is seen, together with the same number of epithelia from the convoluted tubules of the kidney, and a few red blood-corpuscles. These features, when present in such very small numbers, are not sufficient for the diagnosis of an inflammation,

though the urine can not be called normal. In such cases the diagnosis of an *irritation of the kidney* is possible, and in them we will never find casts. As soon as casts are present, even if the features are very scanty, an inflammation must be diagnosed.

In some, though not in all cases of irritation, an increase of mucus, both in the form of threads and corpuscles, is noticeable. When this is present, caution is necessary, since such an increase of mucus is often seen as a pre-stage of an inflammation, especially in acute eruptive and inflammatory diseases, such as scarlet fever, diphtheria, and pneumonia.

Causes.—Irritation of the kidney is of common occurrence, but is frequently overlooked. It may be present accompanying almost any disease, and may be produced by different medicinal agents, such as cubebs, copaiba, turpentine, cantharides, and mineral acids. Occasionally it seems as if simple exposure to cold and moisture is sufficient to produce it. In cases of catarrhal or gonorrhœal urethritis, especially if accompanied by slight prostatitis, irritation of the kidney is often found. The presence of an increased amount of salts, such as uric acid or oxalate of lime, will not infrequently be responsible for the condition.

If the cause which has produced the irritation be quickly removed, the affection may disappear at once; but if not, an inflammation will sooner or later result.

If the irritation is pronounced, a more or less severe *hæmorrhage from the kidney* may take place, even without an inflammation. In such cases, red blood-corpuscles will be numerous, epithelia from the convoluted tubules may be somewhat more abundant, and, in addition, scanty, delicate shreds of connective tissue will appear in the urine. All the features may have a yellowish hue from the coloring matter of the blood.

CATARRHAL OR INTERSTITIAL NEPHRITIS

Catarrhal, interstitial, or desquamative nephritis frequently runs a comparatively mild course, being, as a rule, the mildest of the three varieties of inflammations. Severe acute cases, which may cause the death of the patient, do however, occur. Catarrhal nephritis is a much more common affection than is generally supposed, and may exist for many years without giving any pronounced clinical symptoms. It is by no means

rare that a urine which is examined microscopically with a view of detecting other affections will show the presence of such an inflammation before the clinical symptoms are clear, though the patient may have suffered for a long time from occasional headaches and general depression.

Causes.— Catarrhal nephritis often exists in a mild degree without any known cause. Exposure to cold and moisture seems to be a frequent cause, as are also different medicinal agents, such as arsenic, iodine, phosphorus, mercury, turpentine, and cantharides. In lead-poisoning the disease is often present. It is not infrequently found in persons of sedative habits and in those with a so-called gouty or rheumatic diathesis. That persons suffering from gout and rheumatism usually void a large amount of uric acid is well known; but there are others who continually void uric acid and oxalate of lime in excess without giving any rheumatic symptoms. In these cases — lithæmia and oxaluria — catarrhal nephritis frequently occurs, and it seems that the excess of the salts, or the concentration of the urine itself, has an irritating tendency upon the kidney tissue. The continued use of alcohol is an important factor in the production of the disease.

In acute contagious diseases, croupous nephritis is of more common occurrence than catarrhal, but the latter, contrary to the general belief, undoubtedly occurs. If the urine is carefully examined in these diseases, a small amount of albumin, perhaps not more than a trace, may be found in the milder cases, and upon microscopical examination the features of a catarrhal inflammation are seen. Even in some fatal cases, an examination of the kidney may reveal a catarrhal and not a croupous inflammation. In pregnancy, also, catarrhal nephritis may occur, though rarely.

As a secondary affection, this variety of inflammation may be present in many acute and chronic fatal diseases, so much so that, upon post-mortem examinations, absolutely healthy kidneys are usually found only after death by accident.

Finally, catarrhal nephritis is common as a result of various genito-urinary affections, as, for instance, in some cases of gonorrhœa, when first a prostatitis, then, in succession, a cystitis, pyelitis, and nephritis will develop. In syphilitic and tubercular affections it is frequently seen.

Clinical Symptoms. — The clinical symptoms of the disease

vary greatly, but in the milder cases are anæmia, occipital headache, pain in the lumbar region, loss of appetite, sleeplessness, and general depression. In cirrhosis of the kidney the symptoms are pronounced, loss of flesh and strength is well marked, vomiting may be frequent, there may be dyspnœa, and the pulse is tense, hard, and often full. The acute cases may occur at any age, but the chronic cases are mostly found in persons more advanced in years, especially after the age of forty years.

Features Found in Urine.—Albumin, although present in most of the cases, may be found in very small amount only, and in some it seems to be entirely absent. A large amount of albumin is rare in catarrhal nephritis, and is seen only in the severe cases. In many, a trace of albumin only will be found, and unless a careful observation is made, it may escape detection entirely. The question whether a pronounced inflammation of the kidney may exist with entire absence of albumin is still an open one. Many authors claim that it does occur, but many times when albumin is said to be absent, careful examination will show a trace. It is undoubtedly a fact that in catarrhal nephritis albumin may be absent at certain times; but frequent examination will almost invariably show at least a trace in every case.

The specific gravity, amount, and appearance of the urine will vary greatly. In milder cases, these may be perfectly normal. In acute catarrhal nephritis the specific gravity is, as a rule, somewhat higher than normal, the amount slightly decreased, and the color darker. The amount of urea is usually increased, and salts may be present in rather large numbers. In chronic cases the amount of urine is invariably increased, sometimes to a great degree; the specific gravity is low, and the color pale. In such cases the specific gravity is not infrequently below 1.015 or 1.012 continually, the amount of urea and salts being diminished. The sediment found in the urine varies, but is usually small, and may, at times, be no more abundant than in normal urine.

A positive diagnosis of catarrhal or interstitial nephritis is in many cases possible only by a microscopical examination of the urinary sediment. This will vary in acute, subacute, and chronic cases. The diagnosis of a nephritis can be made when pus-corpuscles and epithelia from the convoluted and narrow

tubules of the kidney are present in the urine. Columnar epithelia from the straight collecting tubules are of rarer occurrence, and indicate an invasion of the pyramidal substance.

Before the presence of epithelia from the convoluted tubules of the kidney can be diagnosed, pus-corpuscles must be found and taken as a standard, since the latter vary in size to a certain degree in every given case. Kidney epithelia from the convoluted tubules are invariably one-third larger than the pus-corpuscles. These epithelia are never found in normal urine, and to render their diagnosis positive, should always be compared with pus- or white blood-corpuscles. A single kidney epithelium is of no value for the diagnosis, as a small number, at least, should always be found, in order to render the diagnosis positive, since, as is well known, pus-corpuscles will vary in size to a small degree even in the same case. This difference is, however, small, and never so pronounced as to render the diagnosis between pus-corpuscles and kidney epithelia difficult. The difference in size between the two can alone determine the nature of the epithelia, since the presence or absence of a nucleus has no significance whatever. A nucleus may be seen in pus-corpuscles as well as in epithelia, though it is found more frequently in the latter than in the former. In finely granular pus-corpuscles a nucleus will always be visible, while in coarsely granular epithelia it may not be seen.

Kidney epithelia from the convoluted, as well as those from the narrow tubules will, in urine generally, have a round form; angular or irregular forms are rarely seen. When the urine is still warm at the time of examination, or in a warm temperature, the pus-corpuscles may not infrequently show amœboid movement, and assume a variety of different shapes while the kidney epithelia will, as a rule, retain their round form.

In this variety of nephritis casts are usually absent; if they are present at all, they are found in extremely small numbers, and then we almost invariably see small hyaline casts from the narrow tubules only. The diagnosis, however, hinges upon the presence of epithelia from the convoluted and narrow tubules and pus-corpuscles, together with other features to be presently mentioned.

Acute Catarrhal or Interstitial Nephritis (Fig. 81).—In an acute catarrhal nephritis the pus-corpuscles and cuboidal epi-

thelia from the convoluted tubules of the kidney are present in at least moderate but usually large numbers; the more numerous these features, the severer is the nephritis. Besides these, we usually find red blood-corpuscles in moderate or large numbers, though they are not sufficiently numerous to admit of the diagnosis of a hæmorrhage. Larger numbers of red blood-corpuscles always indicate an acute inflammation.

These three features are perfectly sufficient for the diagnosis, but are rarely found alone. In many cases different salts, such as oxalate of lime, uric acid, and urate of sodium, will be found in small amount. In the severer cases a few columnar epithelia from the straight collecting tubules are also present. As a general rule, an inflammation of the pelvis of the kidney is associated with the nephritis, though this may be absent. When present, the irregular, lenticular, pear-shaped, or angular epithelia from the pelvis will also be seen in varying numbers, and the diagnosis of a *Pyelo-nephritis* can be made. Such a diagnosis does not by any means suggest an abscess of the kidney, as is frequently supposed, but simply the extension of the inflammatory process to the pelvis of the kidney. Besides these, epithelia from the ureters in small numbers, which are twice the size of pus-corpuscles, and therefore larger than the kidney epithelia, are rarely absent.

If the nephritis is at all pronounced, symptoms of an accompanying cystitis are also seen, and we will then find larger cuboidal epithelia from the middle layers of the bladder—which in urine appear round or oval in most cases—as well as flat epithelia from the upper layers with the other features.

The severer the acute inflammation the more certain are the accompanying features of pyelitis and cystitis. In such severe cases hyaline casts from the narrow tubules are occasionally present; if these are seen in small numbers only, the diagnosis does not necessarily become changed. The latter feature is comparatively rare, and in most cases casts of any kind are entirely absent.

Chronic Catarrhal or Interstitial Nephritis (Fig. 82).—As soon as the inflammation has become chronic, the features in the urine are different. Red blood-corpuscles are now either entirely absent, or, when present, are found in small numbers only. We observe, however, a varying number of small, glistening, highly refractive globules and granules, partly lying free, partly in the

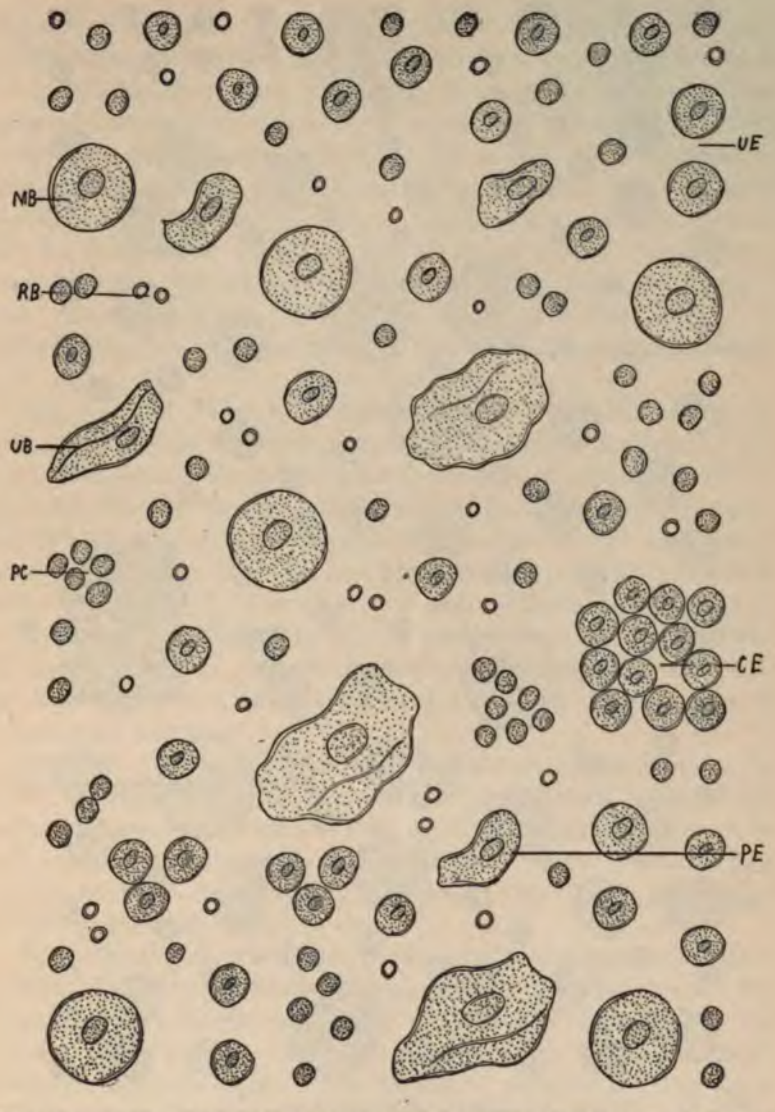

FIG. 81. ACUTE CATARRHAL PYELO-NEPHRITIS (ACUTE INTERSTITIAL NEPHRITIS) AND CYSTITIS (× 500).

RB, red blood-corpuscles ; PC, pus-corpuscles ; CE, epithelia from the convoluted tubules of the kidney ; UE, epithelia from the ureter ; PE, epithelium from the pelvis of the kidney ; UB, epithelium from the upper layers of the bladder ; MB, epithelium from the middle layers of the bladder.

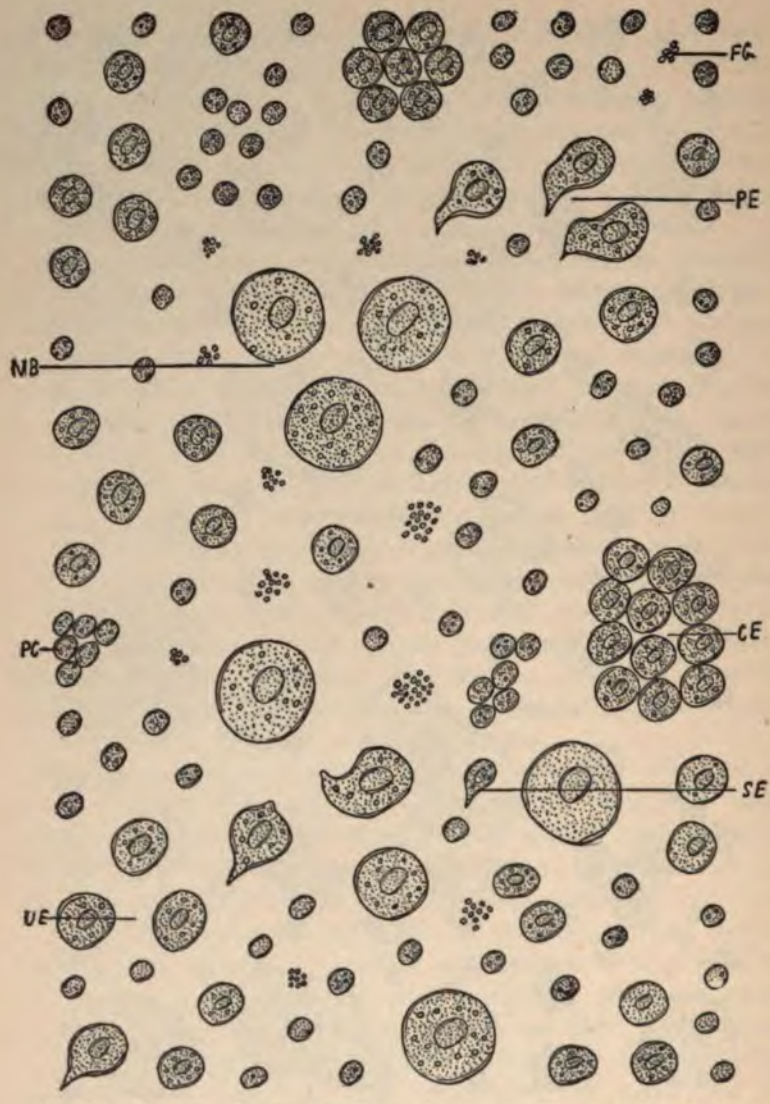

FIG. 82. CHRONIC CATARRHAL PYELO-NEPHRITIS (CHRONIC INTERSTITIAL NEPHRITIS) AND CYSTITIS (× 500).

PC, pus-corpuscles containing fat-globules; CE, epithelia from the convoluted tubules of the kidney containing fat-globules; SE, epithelium from the straight collecting tubules of the kidney containing fat-globules; UE, epithelia from the ureter containing fat-globules; PE, epithelia from the pelvis of the kidney; MB, epithelia from the middle layers of the bladder; FG, free fat-globules.

pus-corpuscles and epithelia. These are fat-globules and -granules, and the more numerous they are, the more chronic is the inflammation. They are found in larger or smaller groups scattered throughout the field, and are seen in varying numbers in the pus-corpuscles and epithelia. In milder cases only two or three may be present in some epithelia, while they will be absent in others; but in the old, chronic cases, almost every epithelium will be seen filled with the glistening globules. When very numerous, they not only denote chronicity, but also a commencing fatty degeneration of the kidney, which, in this variety of nephritis, is never pronounced. Fat-globules are not seen in acute cases.

The features found in a chronic catarrhal nephritis are, therefore, the following: Pus-corpuscles, some containing fat-globules and -granules; cuboidal epithelia from the convoluted tubules of the kidney, a few, or the larger number, containing fat-globules; free fat-globules in different groups; in the severer cases, also, columnar epithelia from the straight collecting tubules, usually in small numbers only. Irregular or round epithelia from the pelvis of the kidney, cuboidal (round) epithelia from the ureters, and still larger cuboidal epithelia from the middle layers of the bladder, either with or without fat-globules, may be present in small or moderate numbers.

Another feature of chronicity which may occasionally be found is hæmatoidin, in the form of rust-brown needles and plates. These may either lie free, or when of small size may be seen in the pus-corpuscles and epithelia. They denote a previously existing hæmorrhage, and show that the pathological process can not be an acute one.

Red blood-corpuscles, as previously mentioned, are either entirely absent in a strictly chronic case, or, when present, are found in small numbers only. Not infrequently, however, all the features of a chronic inflammation are seen, and yet blood-corpuscles are numerous. This invariably denotes a fresh acute outbreak engrafted upon the chronic process. Such acute attacks are not rare in cases of long standing, and may be produced by the slightest cause, such as exposure to cold, derangements of digestion, etc. Again, the chronic inflammation may be confined to one kidney and an acute process affect the second kidney.

In Subacute Catarrhal Inflammations some features of both the acute and the chronic form will be found. We have a small

or moderate number of red blood-corpuscles and a small number of fat-globules, the latter being rarely seen in groups, but only in a few pus-corpuscles and epithelia, and there may be only one, two, or three in them. The other features remain the same.

When the features as here described are present, it will not be difficult to tell whether an inflammation is acute, subacute, or chronic; but some cases may at times be seen where neither red blood-corpuscles nor fat-globules can be discovered, and then the diagnosis of a simple catarrhal or interstitial nephritis can alone be made. These cases are usually of a mild character.

Besides all these features, the appearance of the pus-corpuscles, as noted in a previous chapter, must be taken into consideration, and may help to clear up the case where the clinical features and the history are vague. As long as the constitution of the patient is still fairly good, which can easily be determined by the number of coarsely and finely granular pus-corpuscles present in the case, we may feel confident that the nephritis can not have lasted any length of time, nor be a severe one.

Cirrhosis of the Kidney (Fig. 83).—The outcome of chronic catarrhal nephritis is always a shrinkage — cirrhosis — of the kidney, the so-called hob-nail kidney. The features of this, as seen in the urine, are so characteristic that a positive diagnosis can always be made. They are the following:

1. A large amount of urine, being occasionally increased to double the normal quantity, and the color being pale.

2. A continuously low specific gravity, usually below 1.012 or 1.010, or even not more than 1.006 at any time.

3. The presence of a small amount or perhaps but a trace of albumin.

4. The absence of all salts.

5. Pus-corpuscles, present in small numbers, some containing fat-globules.

6. Epithelia from the convoluted and straight collecting tubules of the kidney, in small numbers, some or even all containing fat-globules.

7. Free fat-globules and -granules.

8. Connective-tissue shreds, of small sizes and in small numbers only.

9. Broken down constitution, as seen by the pale, finely granular pus-corpuscles, in which not infrequently one or more nuclei become plainly visible.

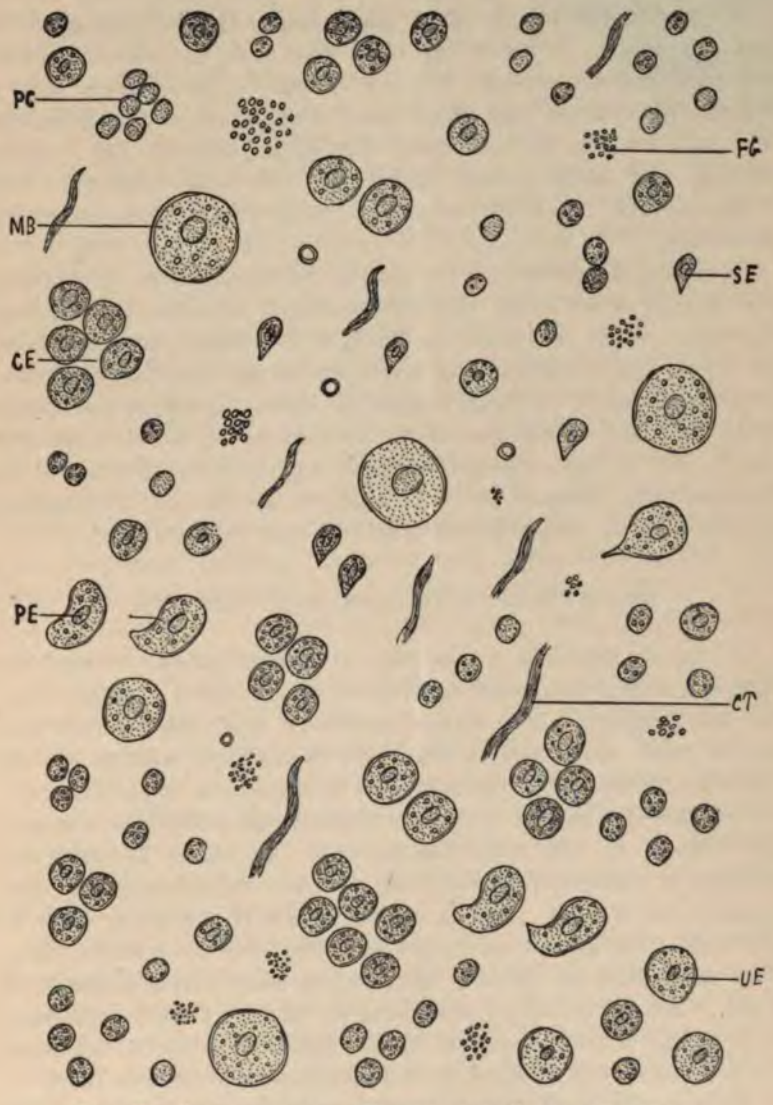

FIG. 83. CIRRHOSIS OF THE KIDNEY, WITH CHRONIC CATARRHAL CYSTITIS (× 500).

PC, pus-corpuscles; CE, epithelia from the convoluted tubules of the kidney, containing fat-globules; SE, epithelium from the straight collecting tubules of the kidney; UE, epithelium from the ureters; PE, epithelium from the pelvis of the kidney; MB, epithelium from the middle layers of the bladder; CT, connective-tissue shreds; FG, free fat-globules.

Epithelia from the pelvis of the kidney, the ureter, and the middle layers of the bladder may also be present.

As previously explained, a badly diseased kidney can never void any salts. In some cases, in which all the other features of a cirrhosis are present, a large amount of salts, such as uric acid or phosphates are also seen. The conclusion which can then be reached, is that only one kidney has so far become affected, the salts being voided by the other kidney. The prognosis will, in such cases, be better than when all salts are absent.

Catarrhal Pyelitis.—A few words should here be said about catarrhal pyelitis, which is occasionally a primary, independent affection. When it occurs as such, it is easily diagnosed from the urine, the features being the same as in catarrhal nephritis, except that pelvic epithelia instead of kidney epithelia are found. Being in many cases due to an abundance of salts, these will usually be present in such cases. As a rule, pyelitis is an accompanying element of a nephritis, giving us a catarrhal pyelo-nephritis, with the features as above described.

CROUPOUS OR PARENCHYMATOUS NEPHRITIS

Croupous nephritis is usually a severer affection than the catarrhal, and is not quite as frequent as the latter. When present, its symptoms are always more or less pronounced, and only in rare cases will it exist for some time without giving symptoms sufficiently characteristic to suspect a nephritis.

Causes.— Its causes are numerous, being partly the same as those found in the catarrhal variety. Exposure to cold and moisture is a common cause, and it is not infrequently the consequence of irritant poisons acting upon the system, such as turpentine, bichloride of mercury, cantharides, arsenic, large doses of iodide of potash, and, occasionally, even chlorate of potash. As in catarrhal nephritis, it may be found in persons of a sedative habit and in those suffering from a lithæmia. The continued use of alcohol is an important causative factor.

Among the most common causes in the production of the disease are the acute eruptive and inflammatory diseases, especially scarlatina, diphtheria, and pneumonia; less frequently typhoid fever and small-pox. It is occasionally seen during pregnancy, though it is not always easy to account for its

occurrence; pressure produced by the gravid uterus may be partly responsible for it. In chronic affections, such as heart diseases, tuberculosis, and syphilis it may also be seen, as well as in rarer cases of malarial poisoning.

As a result of strictures of the urethra, prostatitis, and hypertrophy of the prostate gland, croupous nephritis is frequent. The original inflammation will cause a cystitis, and, from the bladder, ascend to the ureters, pelves, and kidneys, ending in a croupous nephritis. A peculiar occurrence is its appearance in strong, healthy athletes during active training, especially when they subsist upon a meat diet; the same may be the case in fat people who desire to reduce their weight quickly by an exclusive meat diet.

Clinical Symptoms.—The clinical symptoms vary with the intensity of the process, though anæmia, headache, loss of appetite, emaciation, nausea, and loss of strength are all generally present. Severe acute cases may be ushered in by chills, followed by a rise in temperature. Very soon œdema will appear, first being localized, especially on the eyelids, but soon becoming general, involving the face, hands, feet, and cellular tissues generally. To these symptoms will be added dull, aching pains in the lumbar region, and, in the severe cases, uræmic symptoms.

Features Found in Urine.—Albumin is almost invariably present in comparatively large amount, and in some cases may be extremely abundant, reaching one-half of 1 per cent, or even more. It is claimed that occasionally croupous nephritis may exist without the presence of any albumin; that it may exceptionally occur in small quantities only is undoubted; but it will probably never be absent altogether, as careful tests for albumin will show.

In acute croupous nephritis the amount of urine is usually decreased, sometimes to a great degree, and in the severer and fatal cases may sink to a few ounces in the twenty-four hours, or may even be practically suppressed. The specific gravity is in many cases higher than normal, often reaching 1.030 or more, and the color dark, being sometimes quite pronounced, since hæmorrhages frequently occur. The amount of solids, especially urea, voided during the twenty-four hours is usually decreased to a greater or less degree. In chronic nephritis the amount of urine is also at first decreased, but later becomes

more abundant, though never in as pronounced a degree as in chronic catarrhal inflammation. The specific gravity will gradually become lower, until in atrophy of the kidney it is never more than 1.012, or even less. The color varies, being pale in the later stages. The sediment found in the urine is always quite abundant, and when once separated does not readily mix with the watery portion.

As in catarrhal nephritis, a positive diagnosis of croupous or parenchymatous nephritis is, in many cases, possible only from a microscopical examination of the urinary sediment. This will vary considerably in acute, subacute, and chronic cases. In this variety of nephritis the presence of casts in larger or smaller numbers is a constant feature, without which the diagnosis can never be made, and the greater the number of casts, the worse, as a rule, the inflammation. True casts will, however, never be found in urine without the presence at the same time of pus-corpuscles and kidney epithelia, the latter not only from the convoluted and narrow tubules, but frequently, also, from the straight collecting tubules, though these may be absent in mild cases.

The varieties and sizes of the casts are of great importance for the diagnosis and prognosis. In strictly acute cases we never expect to find either granular, fatty, or waxy casts, while hyaline and epithelial casts are always present in larger or smaller numbers, and blood casts in the severer, hæmorrhagic forms. Again, the severity of the process can easily be determined by the size of the casts—when the smallest casts from the narrow tubules alone are present in small numbers, the parenchymatous nephritis will be of a mild character, and recovery is the rule. Casts from the convoluted and narrow tubules together, the former being of medium size, denote a process of moderate severity; but as soon as the largest casts, coming from the straight collecting tubules, are present with the other varieties, we know that the inflammatory process has affected the whole kidney, that is, both cortical and pyramidal substance, and is a severe one; therefore a doubtful prognosis only can be given.

Acute Croupous or Parenchymatous Nephritis (Fig. 84). —When we examine the urine from a case of acute croupous nephritis, the features are found to be numerous and characteristic. The most pronounced elements are undoubtedly the casts,

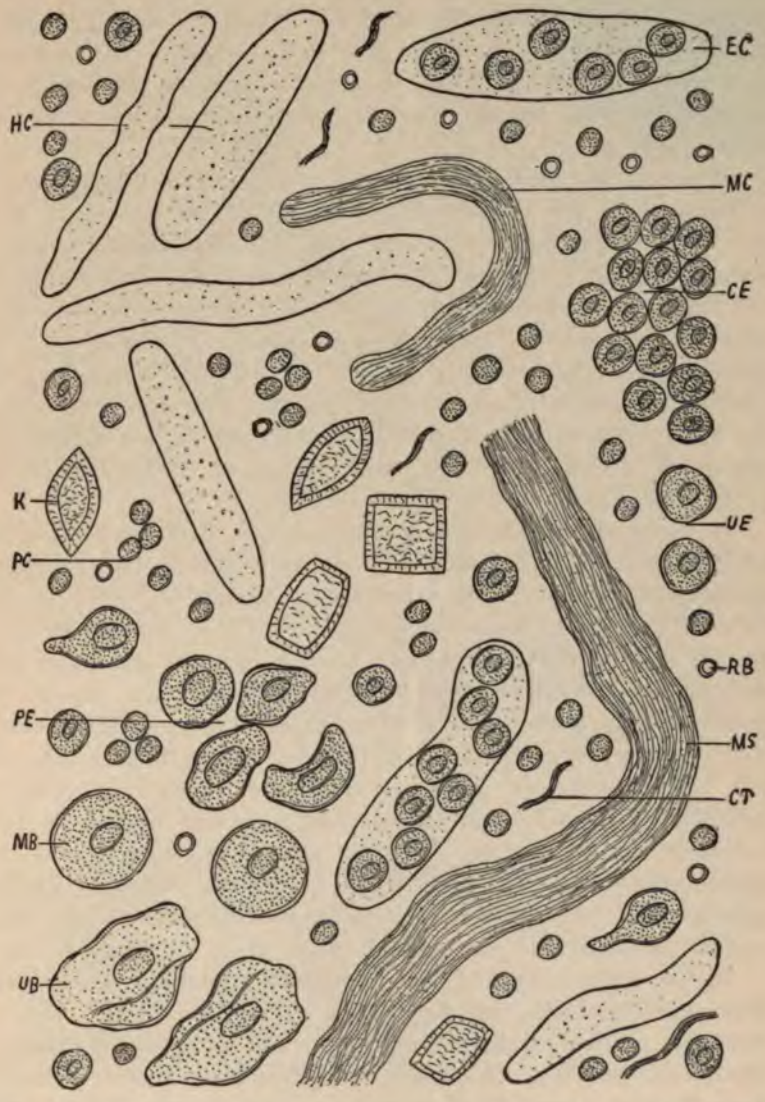

FIG. 84. ACUTE CROUPOUS OR PARENCHYMATOUS NEPHRITIS WITH CATARRHAL PYELITIS AND CYSTITIS (× 500).

RB, red blood-corpuscle; PC, pus-corpuscles; CE, epithelia from the convoluted tubules of the kidney; UE, epithelia from the ureter; PE, epithelia from the pelvis of the kidney; UB, epithelia from the upper layers of the bladder; MB, epithelia from the middle layers of the bladder; K, creatinine crystal; HC, hyaline casts; EC, epithelial cast; MS, mucus-thread; MC, mucus-casts; CT, connective-tissue shred.

which are seen in varying numbers in every field of the microscope. In such cases, two varieties of casts are usually found — the hyaline and the epithelial, the latter studded with epithelia to a greater or less degree. The more numerous the casts, the severer the inflammation, and the more albumin the urine will usually contain.

Besides the casts, pus-corpuscles, red blood-corpuscles, and epithelia from the convoluted tubules are always present. They are found in moderate or large numbers, the kidney epithelia being frequently seen massed together. Red blood-corpuscles are found in every field, though, unless a hæmorrhage has taken place, they cannot be called very abundant. Epithelia from the straight collecting tubules may also be seen, and those from the ureter and pelvis of the kidney almost invariably accompany the other features. As a rule, there will also be an accompanying acute cystitis, shown by the presence of epithelia from the upper and middle layers of the bladder.

In these acute cases, mucus is present in fairly large amount, the pale threads being sometimes of considerable size, irregular, and finely striated. Not infrequently mucus is found in the form of casts — the so-called cylindroids. The presence of these has no further significance than the presence of mucus in general, and they may be seen in inflammations of any one of the genito-urinary organs. When they exist in a pronounced form, they can hardly be mistaken, as they are always faintly striated; but not infrequently they are so faint that their striation becomes visible only upon sharp focusing, and caution is here necessary not to mistake them for hyaline casts, which is frequently done. In size and shape they may resemble hyaline casts, which latter, however, are never striated. When they assume an irregular, convoluted form, their diagnosis is easy.

In the severer cases of acute croupous nephritis, small shreds of connective tissue will be present; they are never large or numerous, and their higher refraction and pronounced fibrillary structure is sufficient to differentiate them from mucus. Besides these features, crystals of creatinine may be present in those cases in which uræmic convulsions have made their appearance. The plate is taken from a case of severe nephritis, which developed in the third week of scarlet fever, and caused the death of the patient. The urine contained large numbers of characteristic creatinine lozenges and plates.

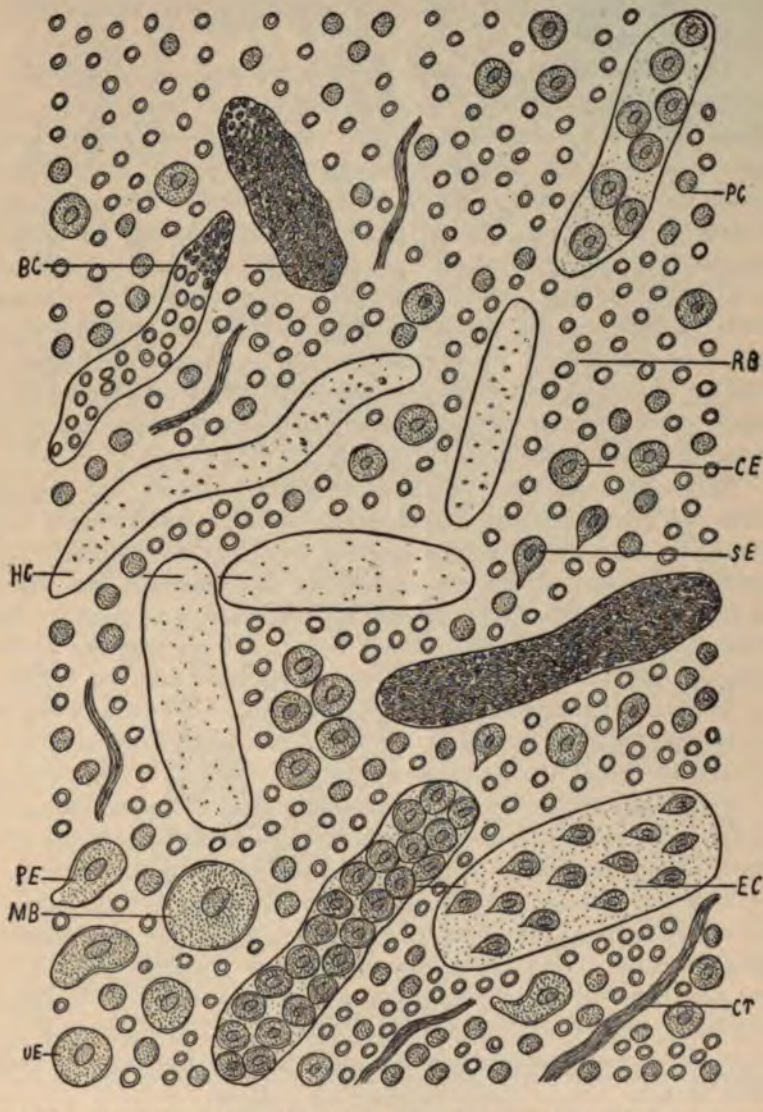

FIG. 85. ACUTE HÆMORRHAGIC CROUPOUS OR PARENCHYMATOUS NEPHRITIS WITH CATARRHAL PYELITIS AND CYSTITIS (× 500).

RB, red blood-corpuscles; PC, pus-corpuscles; CE, epithelia from the convoluted tubules of the kidney; SE, epithelia from the straight collecting tubules of the kidney; UE, epithelium from the ureter; PE, epithelium from the pelvis of the kidney; MB, epithelium from the middle layers of the bladder; HC, hyaline casts: EC, epithelial cast; BC, blood casts; CT, connective-tissue shred.

Besides the cases just described, severe cases with pronounced hæmorrhages are often seen, and will give somewhat different features (Fig. 85).

The urinary sediment contains a large number of red blood-corpuscles in every field, together with many blood casts. The blood casts are partly filled with red blood-corpuscles, which have retained their normal appearance, and partly with disintegrated blood-globules, in the form of irregular brown masses, giving to the whole cast a rust-brown appearance; blood casts assume this character when they have been retained in the tubules for some time. Sometimes the larger portion of the cast contains fully formed red blood-corpuscles, while the disintegration has commenced in a small portion. Besides these casts, hyaline and epithelial casts are found in large numbers, and in these cases we almost invariably find large casts from the straight collecting tubules.

Epithelia from the straight collecting tubules are usually quite abundant, and connective-tissue shreds are larger and more numerous than in the preceding. In an active hæmorrhage such connective-tissue shreds are cast off in fair numbers and found in the urine. Sometimes masses of fibrin are also found. The other features are the same, there being in most cases an accompanying inflammation of the pelves, the ureters, and the bladder.

Subacute Croupous Nephritis (Fig. 86).—After a croupous or parenchymatous nephritis has lasted for some time, the casts, or rather some of the casts, commence to change. Such a change is rarely noticed until four or six weeks after the commencement of the inflammation, but occasionally, especially in nephritis after scarlet fever in children, may take place in two or three weeks.

The first change will be seen in the epithelial casts, some of the epithelia breaking down into granules, giving us an epithelial-granular cast. Very soon, however, perfect granular casts, without any trace of epithelia, are also found in small or moderate numbers, and these, in exceptional cases in children, can be seen as early as two weeks after the inflammation has started, being then scanty.

The next change which takes place is the transition of the granules into glistening, refractive fat-granules and -globules, at first only two or three being noticeable in a granular cast, and later on a larger number. Traces of the original epithelia may still be seen in the cast, while the largest portion has become

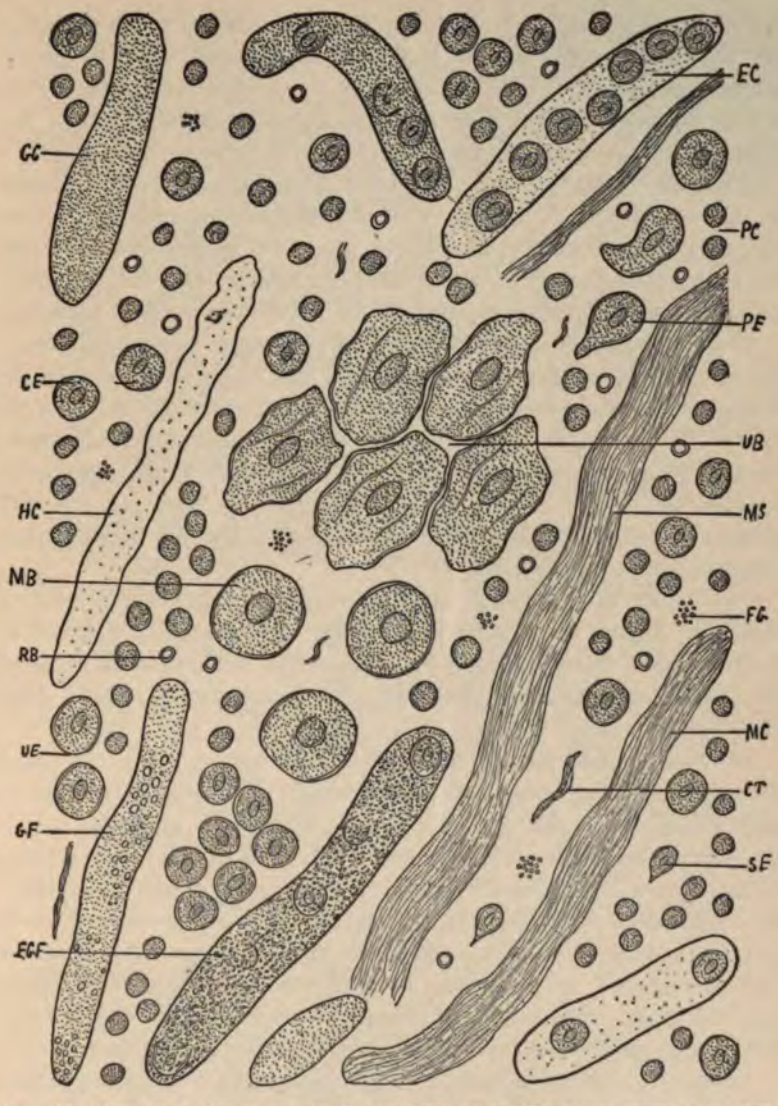

FIG. 86. SUBACUTE CROUPOUS OR PARENCHYMATOUS NEPHRITIS WITH CATARRHAL PYELITIS AND CYSTITIS (× 500).

RB, red blood-corpuscle; PC, pus-corpuscles; CE, epithelia from the convoluted tubules of the kidney; SE, epithelium from the straight collecting tubules of the kidney; UE, epithelia from the ureters; PE, epithelium from the pelvis of the kidney; UB, epithelia from the upper layers of the bladder; MB, epithelia from the middle layers of the bladder; HC, hyaline cast; EC, epithelial cast; GC, granular cast; GF, granular-fatty cast; EGF, epithelial-granular-fatty cast; MS, mucus-thread; MC, mucus-cast; CT, connective-tissue shred; FG, free fat-globules.

changed into granules, and some of the granules into fat-globules, and we now have epithelial-granular-fatty casts. When the inflammation has lasted for six weeks or two months, small groups of free fat-globules, at first scanty, are also found, and a few globules are seen in the epithelia.

The other features, usually present in moderate numbers only, are the same as in an acute croupous nephritis, and connective-tissue shreds are scanty, unless the case is a severe one. Mucus-threads and casts may at times be pronounced, and the accompanying inflammations, especially in the bladder, are well marked.

Chronic Croupous Nephritis.—The longer a nephritis lasts, the more marked are the changes in the casts, and in strictly chronic cases neither hyaline nor epithelial casts are seen in the urine. The granular casts are the most abundant in the milder forms, though a few fatty casts or granular-fatty casts are also present. The groups of free fat-globules, as well as the fat-globules in the epithelia and pus-corpuscles, become more numerous and more pronounced.

In almost all cases of chronic croupous or parenchymatous nephritis, which have lasted for many months, and, instead of abating have become more pronounced, a *fatty degeneration of the kidney* will develop, and we now have the so-called *large white kidney* (Fig. 87).

In these cases, the fatty casts are abundant, and the large casts from the straight collecting tubules are frequently seen in conjunction with the smaller casts. The fatty changes in the pus-corpuscles and epithelia are well marked, and the groups of free fat-globules and -granules large and numerous. Here, too, individual fat-globules, much larger than those ordinarily seen, and sometimes attaining three or four times their size, or even more, may be present. In rare cases, needles of margaric acid in small numbers are found, but these are exceptional. Red blood-corpuscles are scanty in the majority of these cases.

Connective-tissue shreds are always present, and may attain large sizes, being fairly abundant. The evidences of chronicity, as shown by the fat-globules, will be seen in all epithelia found in the urine; that is, both those from the convoluted and straight collecting tubules of the kidney, from the pelvis, the ureters, and the bladder. The epithelia from the straight collecting tubules are sometimes numerous, and may be just as abundant as the cuboidal epithelia. Pelvic epithelia are never

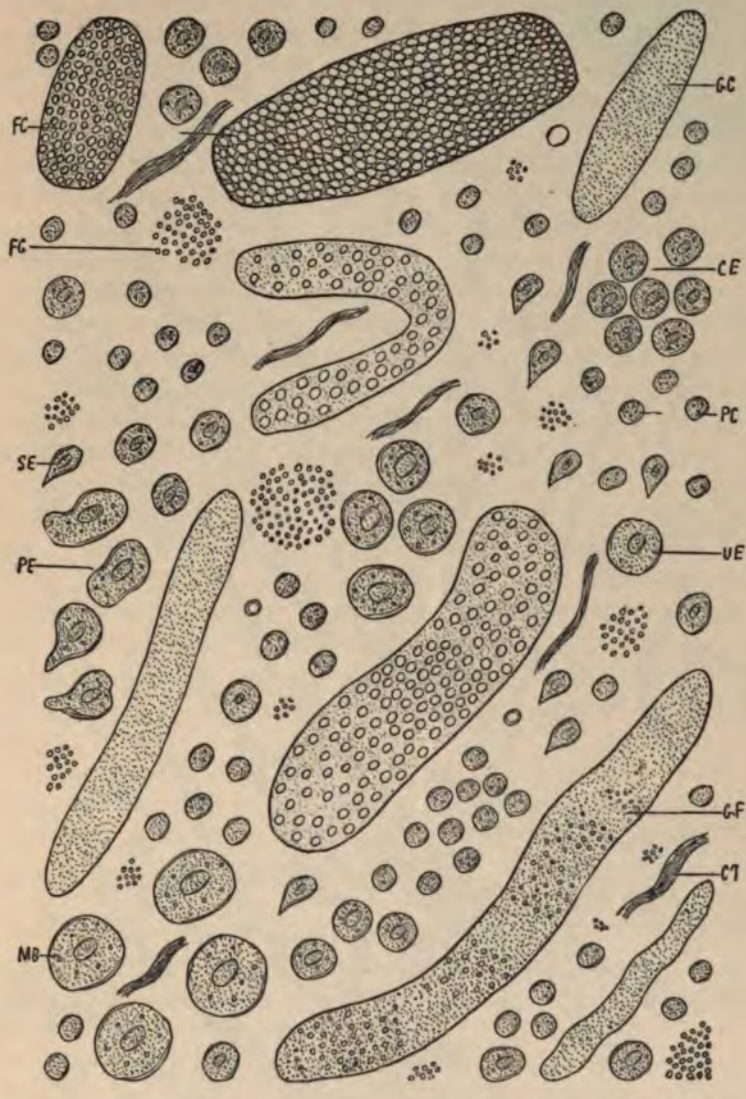

FIG. 87. CHRONIC CROUPOUS OR PARENCHYMATOUS NEPHRITIS WITH FATTY DEGENERATION OF THE KIDNEY, ACCOMPANYING CATARRHAL PYELITIS AND CYSTITIS (× 500)

PC, pus-corpuscles; CE, epithelia from the convoluted tubules of the kidney; SE, epithelia from the straight collecting tubules of the kidney; UE, epithelium from the ureter; PE, epithelia from the pelvis of the kidney; MB, epithelia from the middle layers of the bladder; GC, granular cast; FC, fatty casts; GF, granular-fatty casts; CT, connective-tissue shreds; FG, free fat-globules.

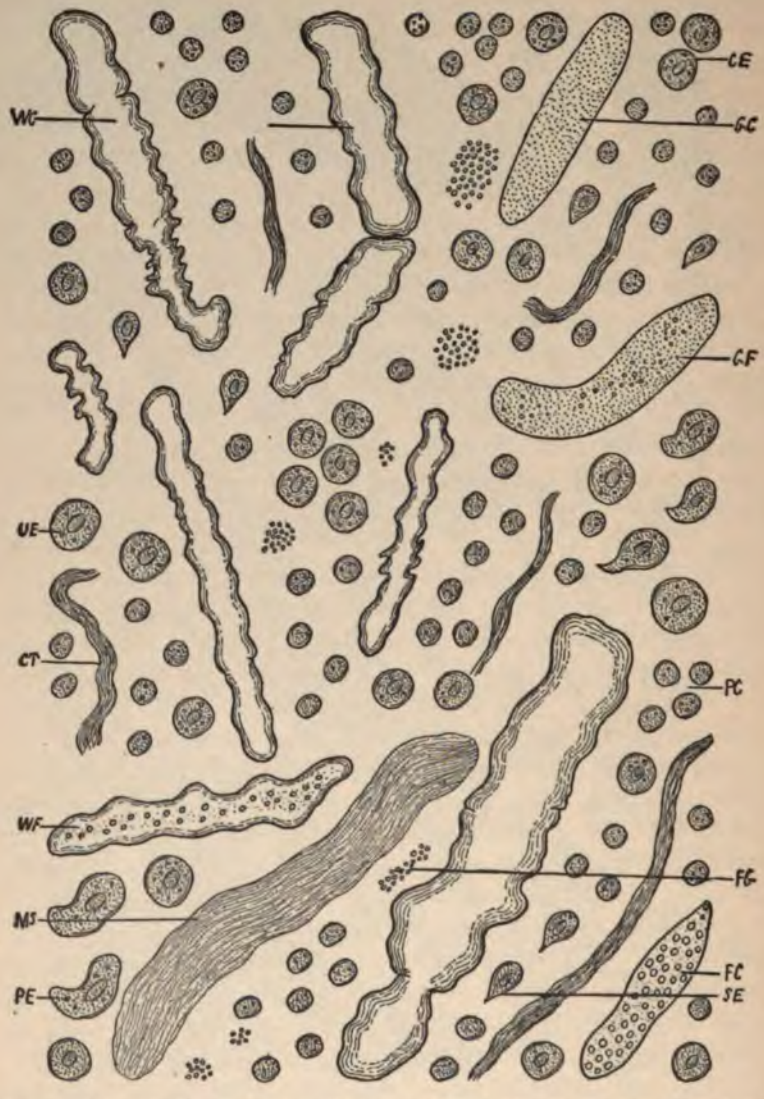

FIG. 88. CHRONIC CROUPOUS OR PARENCHYMATOUS NEPHRITIS, WITH FATTY AND WAXY DEGENERATION OF THE KIDNEY, ACCOMPANYING CATARRHAL PYELITIS (× 500).

PC, pus-corpuscles ; CE, epithelia from the convoluted tubules of the kidney ; SE, epithelia from the straight collecting tubules of the kidney ; UE, epithelia from the ureter ; PE, epithelia from the pelvis of the kidney ; GC, granular cast ; GF, granular-fatty cast ; FC, fatty cast ; WC, waxy cast ; WF, waxy-fatty cast ; MS, mucus-thread ; CT, connective-tissue shred ; FG, free fat-globules.

absent, and those from the ureters are well marked. That a cystitis of varying degrees of intensity is always present need hardly be mentioned.

Besides the fatty degeneration, a *waxy or amyloid degeneration of the kidney* is found in a number of cases. Some authors call this an amyloid disease of the kidney and claim that it is an independent affection, and not associated with a parenchymatous nephritis. This view is undoubtedly incorrect, as a waxy degeneration of the kidney is always a secondary affection found in chronic cases of nephritis. The exact cause and nature of such a degeneration are not known, and it is mostly found in chronic diseases, such as syphilis, tuberculosis, suppurative processes, ulcerations, and necroses. It seems to be due to some chemical change in the plasma of the blood, though the nature of this change is unknown.

Waxy degeneration of the kidney may occur in both catarrhal and croupous nephritis; it is much more common in the latter, and is rare in the former. It invades the epithelia of the uriniferous tubules, and ultimately produces waxy casts. Epithelia which have become waxy are highly glistening, and are found in the urine as more or less shining, homogeneous bodies. Not only the epithelia, but also the connective tissue, and simultaneously the walls of the blood-vessels, may undergo waxy degeneration.

The appearance of the urine is not characteristic of this degeneration, and it will present the features of a chronic nephritis, though the amount of sediment greatly varies, being sometimes slight, sometimes abundant. The specific gravity is usually low, and the amount of urine voided above normal. The diagnosis should never be made unless the changes in the urinary features are pronounced, and care must be taken not to mistake hyaline casts, which may in rare cases be somewhat glistening, for waxy casts.

In chronic croupous nephritis with waxy degeneration of the kidney, the most characteristic features are the waxy casts (Fig. 88).

Waxy casts may occur in all sizes, are always of a high refraction, have wavy, convoluted contours, and frequently a yellowish color. The casts may assume different forms, and not rarely are so tortuous as to be likened to a cork-screw. In most cases, all the three sizes of waxy casts will be found, and they

may sometimes be mixed with other elements, such as granules—the granular-waxy; or with fat-globules—the fatty-waxy casts. The other features are the same as those in any chronic croupous nephritis. Pus-corpuscles are always present, as well as different epithelia, connective-tissue shreds in large numbers, and granular as well as fatty casts. The appearance of a waxy degeneration is always of grave import, though even here recoveries have occurred, especially in children.

Cystic degeneration, which is also a secondary change, found in chronic cases of nephritis, does not give any characteristic symptoms in the urine, and, therefore, can not be diagnosed as such.

Atrophy of the Kidney.—The result of a chronic croupous or parenchymatous nephritis is invariably atrophy of the kidney. The features of atrophy, as found in the urine, are characteristic, and a positive diagnosis can always be made, though the amount of urine voided in the twenty-four hours varies, and is never as abundant as in cirrhosis of the kidney. The features are the following:

1. A continuously low specific gravity, as a rule, never above 1.010, and occasionally not more than 1.006 or 1.004 at any time.
2. The presence of a large amount of albumin, in contradistinction to the small amount found in cirrhosis.
3. The absence of all salts.
4. Pus-corpuscles, present in moderate numbers, many, if not all containing fat-granules and -globules.
5. Epithelia from the convoluted and straight collecting tubules of the kidney, in moderate numbers, many or all containing fat-granules and -globules.
6. Free fat-granules and -globules, sometimes in large numbers.
7. Granular, fatty, and, in some cases, even waxy casts in varying numbers, the former being usually quite abundant.
8. Connective-tissue shreds of moderate or large size, and always in at least fair numbers.
9. Broken down or poor constitution, as seen by the pale, finely granular pus-corpuscles, in which one or more nuclei are usually visible.

Epithelia from the pelvis of the kidneys, the ureters and the middle layers of the bladder will be present in variable numbers.

Here, again, attention must be called to the fact that a badly

diseased kidney, as an atrophied kidney always is, can never void any salts. In those cases in which salts are present, though all the other features admit of a positive diagnosis of atrophy of the kidney, we can reach the conclusion that only one kidney is as yet affected, since the salts must be voided by the other kidney. In such cases it will always be noticed that the constitution, although greatly impaired, can not as yet be called poor, since, though many pus-corpuscles are finely granular and pale, some will still show a moderately coarse granulation. The prognosis in all such cases is considerably better than when no salts whatever are seen.

Chronic Croupous Nephritis, with Acute Croupous Recurrence.—In many cases of chronic croupous nephritis, acute recurrences may occur at any time, and fresh portions of the kidney tissue become inflamed. Such acute recurrences can, in some individuals, be produced upon the slightest cause, as exposure to cold or errors in diet. It is not uncommon for a recurrence of this kind to be produced every few weeks or months, leaving the patient weaker every time, and finally resulting in death.

A case of this kind, in which an acute croupous hæmorrhagic recurrence took place in a young man of twenty years, is shown in Fig. 89.

In this case, which ended fatally, all six varieties of casts, and of all three sizes, were present in large numbers. Not only were the regular casts seen, but a number of different combinations. The casts present were hyaline, epithelial, blood, granular, fatty, waxy, granular-fatty, epithelial-waxy, blood-waxy and fatty-waxy.

Red blood-corpuscles were present in every field in moderately large numbers, and variously sized groups of fat-globules were also abundant. Pus-corpuscles were numerous, and epithelia from the convoluted as well as the straight collecting tubules of the kidney were present in large numbers, many studded with fat-globules. Connective-tissue shreds were present, and mucus in the form of threads, and especially casts, could be seen in many fields. Of the accompanying inflammations, the pyelitis was the most severe, though the inflammation of the ureters and bladder were well marked.

Salts were entirely absent and the constitution was very poor, so that the diagnosis of probably both kidneys being affected in

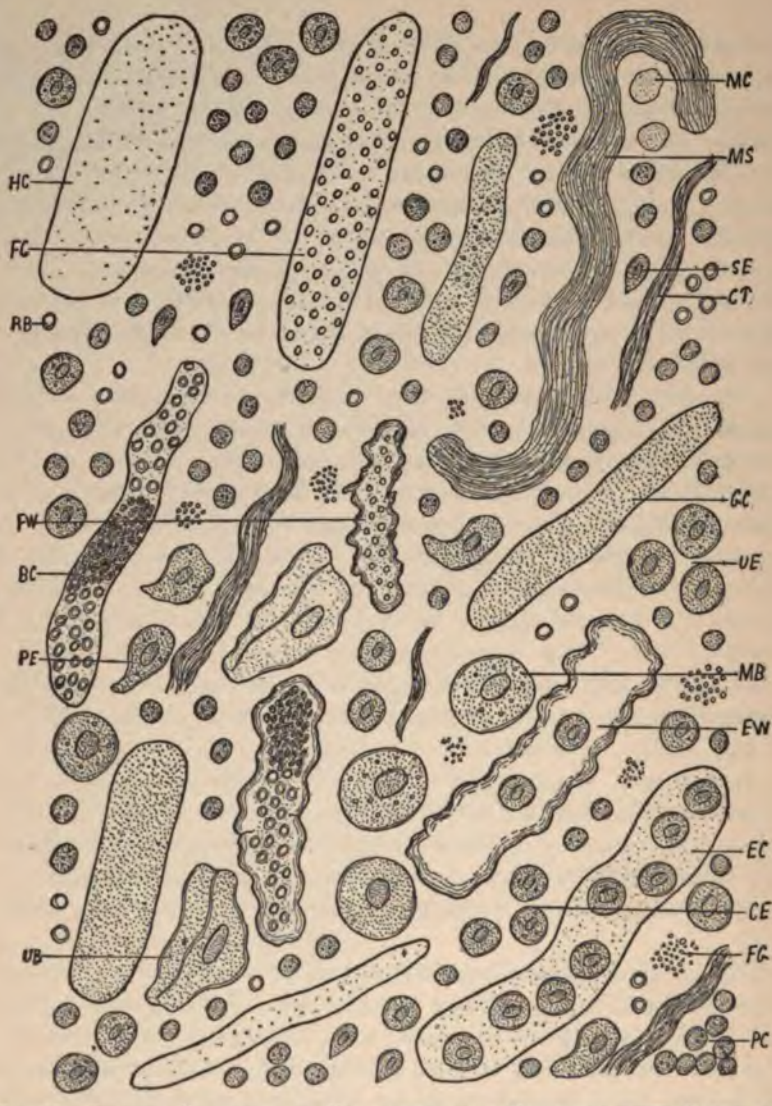

FIG. 89. CHRONIC CROUPOUS OR PARENCHYMATOUS NEPHRITIS WITH FATTY AND WAXY DEGENERATION OF THE KIDNEY AND AN ACUTE HÆMORRHAGIC CROUPOUS RECURRENCE, CATARRHAL PYELITIS AND CYSTITIS (× 500).

RB, red blood-corpuscles; PC, pus-corpuscles; CE, epithelia from the convoluted tubules of the kidney; SE, epithelia from the straight collecting tubules of the kidney; UE, epithelia from the ureter; PE, epithelia from the pelvis of the kidney; UB, epithelium from the upper layers of the bladder; MB, epithelium from the middle layers of the bladder; HC, hyaline cast; EC, epithelial cast; BC, blood cast; GC, granular cast; FC, fatty cast; FW, fatty-waxy cast; EW, epithelial-waxy cast; CT, connective-tissue shred; MS, mucus-thread; MC, mucus-corpuscle; FG, free fat-globules.

a severe degree, and a bad prognosis, had to be given. The patient died within two weeks after the examination.

From the descriptions here given, it will be seen that the casts found in croupous or parenchymatous inflammations of the kidney will always show whether the process is acute, subacute, or chronic. When hyaline, epithelial, or blood casts are found in a case giving all the symptoms of chronicity, we can be certain either that an acute recurrence has taken place in the same kidney, or that the second kidney has become acutely inflamed. Sometimes cases of a so-called acute inflammation will show granular and even fatty casts in large numbers, but careful questioning of the patient will bring out the fact that he has not been perfectly healthy for a long time, though he may have been able to attend to his business in spite of headache and general malaise. The only cases in which purely granular casts in small numbers may occasionally be seen two or three weeks after the commencement of the inflammation, are those already mentioned: in children after scarlet fever. Waxy casts will never appear in acute inflammations, but always denote chronicity.

SUPPURATIVE NEPHRITIS

Suppurative nephritis, also called abscess of the kidney, pyo-nephrosis, or surgical kidney, the most intense of the three primary varieties of nephritis, is an independent process, and must not be confounded with acute interstitial nephritis or pyelo-nephritis, as is frequently done. There may be either a number of small, disseminated foci of suppuration, or one large abscess, usually confined to one kidney. Sometimes the suppuration may be so excessive that the larger part of the structure of the kidney has disappeared, and a large, thick-walled cavity filled with pus is found in its place.

Causes.—The causes of a pyo-nephrosis are not always plain, though in many cases the disease is the result of an extension of the inflammatory process from some other portion of the genito-urinary tract. A simple gonorrhœa, which gradually extends upward, may be sufficient to cause it, and both urethral strictures and inflammation and hypertrophy of the prostate gland may be causes. The use of unclean sounds and catheters,

even in these days of antisepsis, is not rarely followed by a pyo-nephrosis.

Occasionally the disease follows different acute infectious diseases, such as typhus and typhoid fevers, cholera, and diphtheria, or may be seen with pyæmia and carbuncles. In renal tuberculosis, abscesses are quite common, and they may also occur when calculi are present. In still other cases the ætiology remains obscure, and we can only surmise that pyogenic organisms in large numbers have settled in a perhaps previously inflamed kidney.

Clinical Symptoms.—Acute abscesses are usually ushered in by pronounced chills, followed by a rise in temperature and general depression. Pain, as a rule, is present, although it is not always referred to the seat of the abscess. Emaciation, nausea, and vomiting can occur. After an abscess has ruptured, it may continue to discharge pus for a long time, becoming chronic. In these cases the acute symptoms gradually subside, though a slight fever is always present, and pain or tenderness either in the region of the kidney, or in the inguinal region, testicles, or legs, is a constant feature.

Features Found in Urine.—The urine in pyo-nephrosis is always cloudy, and a pronounced heavy sediment invariably forms. The specific gravity varies considerably, but is mostly below normal, and the amount of urine is diminished. Albumin is present in large amount in every case.

The clinical symptoms are at times so vague that a positive diagnosis is generally possible only through a microscopical examination of the urinary sediment. The features found under the microscope will at once clear up the diagnosis, and it does not seem necessary for the abscess to have ruptured; emigrated pus-corpuscles and the shedding of connective-tissue shreds are sufficient for a diagnosis as long as no firm membrane has formed around the abscess.

The microscopical features are the presence of an enormous number of pus-corpuscles, many kidney epithelia, usually from both the convoluted and straight collecting tubules, and a varying number of red blood-corpuscles, the latter being very numerous in acute abscesses. Besides these, connective-tissue shreds are always found, either in moderate or large amount. Without such shreds, abscess of the kidney should never be diagnosed, since these alone show a destruction of the kidney

tissue. Epithelia from the pelvis of the kidney almost invariably accompany the affection. Casts may be either present or absent; when present, they denote a complicating croupous nephritis.

The features seen in a chronic suppurative nephritis are shown in Fig. 90.

The pus-corpuscles are extremely numerous, and may so entirely fill some fields that no other features become visible. In other fields, however, epithelia from the convoluted tubules of the kidney will be found in large numbers, and, as a rule, those from the straight collecting tubules are also present. Fat-globules and -granules are abundant, partly lying free in variously sized groups, partly filling the pus-corpuscles and epithelia to a greater or less degree. Connective-tissue shreds are present, being large and abundant.

Red blood-corpuscles are always found, but in such cases in small numbers only, while not infrequently rust-brown crystals of hæmatoidin, in the form of needles and plates, but especially the former, denoting a previous hæmorrhage, are seen. These will be found in the pus-corpuscles and epithelia, as well as free. In the case depicted, the hæmatoidin crystals were very abundant, being found in the form of large conglomerations of irregular, curved needles and stars, as well as smaller plates. Epithelia from the pelvis of the kidney, the ureter, and the bladder, denoting an inflammation of these organs, are also fairly numerous. In addition, numerous bacteria are usually present.

Although these features are perfectly characteristic, we not infrequently find another, the so-called endogenous new-formation of pus-corpuscles in the pelvic epithelia, denoting, if present in large numbers, a pressure upon the pelvis. Such a diagnosis will, therefore, hardly ever present any difficulties, contrary to the opinion frequently held that it is impossible to diagnose an abscess from the examination of the urine alone.

Abscesses not directly in the kidney substance, but pressing upon the kidney — perirenal abscess, — may also be diagnosed. These will show the same features in the urine, though perhaps somewhat less marked, together with endogenous new-formations in the kidney epithelia. Whenever these are seen in many epithelia, they are caused by long continued pressure upon the kidney, and will justify the diagnosis.

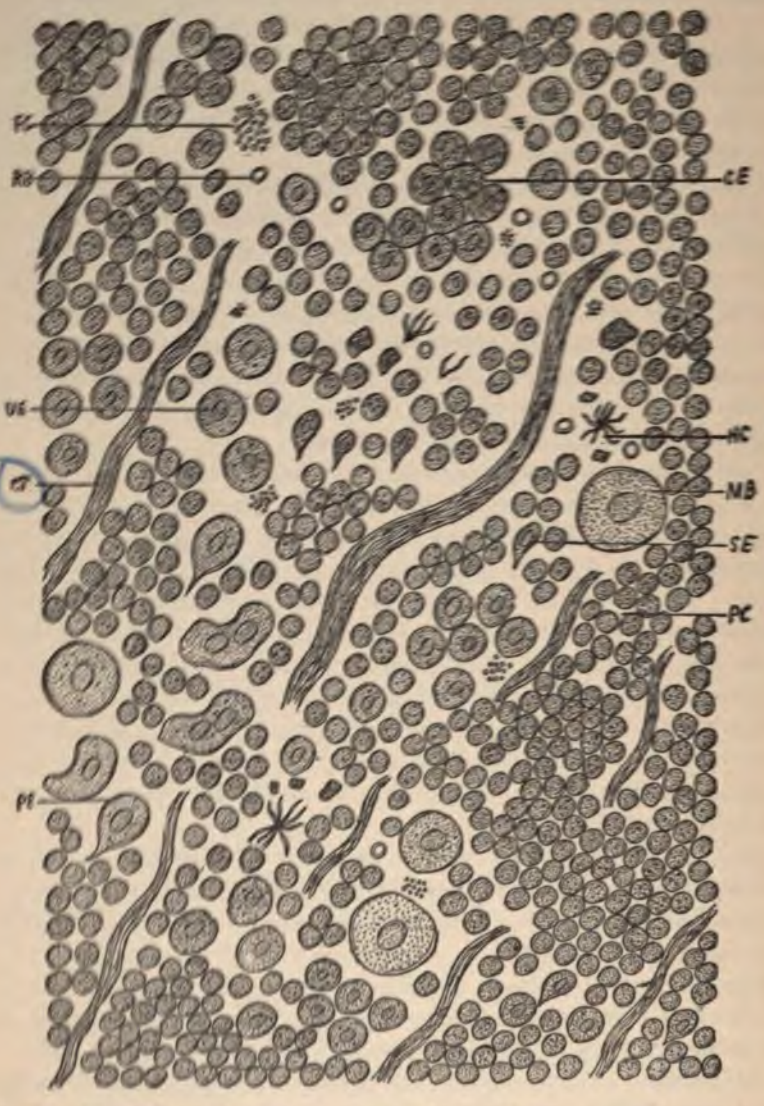

FIG. 90. CHRONIC PYO-NEPHROSIS OR CHRONIC SUPPURATIVE NEPHRITIS, WITH CATARRHAL PYELITIS AND CYSTITIS (× 500).

RB, red blood-corpuscle; PC, pus-corpuscles; CE, epithelia from the convoluted tubules of the kidney; SE, epithelium from the straight collecting tubules of the kidney; UE, epithelia from the ureter; PE, epithelia from the pelvis of the kidney; MB, epithelium from the middle layers of the bladder; CT, connective-tissue shreds; HC, hæmatoidin crystals; FG, free fat-globules.

SUPPURATIVE PYELITIS

An abscess may develop in the pelvis of the kidney instead of in the kidney proper. The causes of this will be the same as for pyo-nephrosis, though perhaps calculi will more frequently produce an abscess here than in the kidney proper. The symptoms do not differ from those of suppurative nephritis, and the exact location of the abscess can only be determined by microscopical examination of the urine (Fig. 91).

In an acute suppurative pyelitis, red blood-corpuscles are always present in moderate or even large numbers, and pus-corpuscles are extremely numerous. The diagnosis can be made from the cuboidal and irregular pelvic epithelia, which in these cases are abundant, and may be found in groups. In such abscesses, epithelia from all the different layers of the pelvis will be present. These epithelia may vary considerably in size, and a few may be even as large as those from the middle layers of the bladder. There will, however, be no difficulty in diagnosing them, since these large epithelia are irregular, angular, lenticular, or pear-shaped. Connective-tissue shreds are numerous, and without them no such diagnosis must be made.

In all cases epithelia from the ureter, showing a secondary inflammation, are quite abundant, and in many of them endogeneous new-formations of pus-corpuscles will be found. Epithelia from the convoluted tubules of the kidney need not necessarily be present in acute cases, but sooner or later a moderate number, the indication of an accompanying nephritis, will be seen ; here, too, endogenous new-formations can appear. Very soon a cystitis will develop, and the epithelia from the bladder accompany the other features.

In a chronic abscess of the pelvis, the features will be the same as those described in suppurative nephritis, except that the comparative number of the pelvic and kidney epithelia becomes changed, the former being considerably more numerous than the latter.

TUBERCULOSIS OF THE KIDNEY

Although renal tuberculosis can undoubtedly exist as a primary disease, it is comparatively rare, being most frequently associated with tuberculosis in other organs. It may result from an extension of the tubercular process from other portions of the

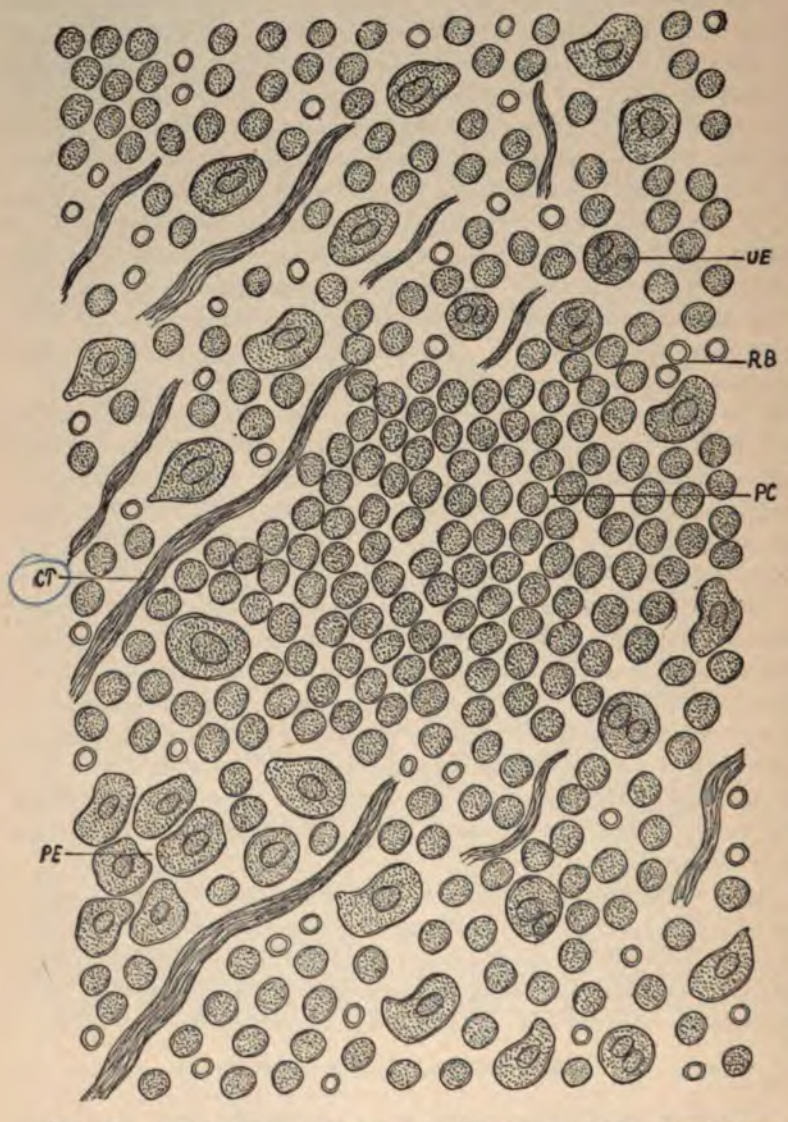

FIG. 91. ACUTE ABSCESS OF PELVIS OF KIDNEY, OR ACUTE SUPPURATIVE PYELITIS (× 500).

RB, red blood-corpuscles; PC, pus-corpuscles; UE, epithelium from the ureter; PE, epithelia from the pelvis of the kidney; CT, connective-tissue shreds.

genito-urinary tract. In the kidney we will generally find evidences of a chronic catarrhal or interstitial nephritis, though in rare cases a croupous or parenchymatous inflammation accompanies the tubercular process. The tubercular nodules in different portions of the kidney enlarge, and, after a time, usually break down, so that ulcers or abscesses are formed.

Features Found in Urine.— The appearance of the urine is not characteristic in these cases; the color is usually pale, and it is turbid and of a low specific gravity. The amount of urine is increased, and a small amount, sometimes only a trace, of albumin is present. The sediment is slight, unless ulcers or abscesses have formed, when it is more profuse.

The features under the microscope are at first those described in a chronic catarrhal nephritis, and later on give evidences of a destructive process, with the presence of connective-tissue shreds in varying amount. In most cases a pronounced cystitis is associated with the process, and not rarely ulcers will be formed in the bladder. Such a chronic ulcerative cystitis should always be looked upon with suspicion, as being possibly due to a tuberculosis.

Whenever tuberculosis is suspected in the kidneys, and the evidences of a chronic interstitial nephritis are found in the urine, examinations for tubercle bacilli must be made. This is not infrequently a tedious process, as the bacilli are rarely present in large numbers; yet the diagnosis can not be made with certainty without them. Repeated examinations of many drops, from urine taken at different times of the day, will never fail to reveal them.

Too much stress can not be laid upon the constitution of the patient, as shown by the appearance of the pus-corpuscles, in such cases. As long as the larger numbers of the pus-corpuscles are coarsely granular and glistening, showing a good constitution, the presence of tuberculosis is not probable. As soon, however, as the pus-corpuscles, or a large number of them, are pale and finely granular, showing a considerably impaired or poor constitution, the existence of a possible tuberculosis must not be lost sight of. Such a poor constitution, with the evidences of only a moderate catarrhal nephritis and cystitis, may not infrequently be among the first suspicious signs of tuberculosis, even when the clinical symptoms are as yet only slightly pronounced.

II. *ANOMALIES OF SECRETIONS*

Of great importance in the diagnosis of kidney lesions are the anomalies of secretion, under which term the conditions known as *Lithæmia* and *Oxaluria* are included. Sooner or later these will in many cases produce an inflammation of the kidney proper, as well as the pelvis of the kidney, and may in pronounced cases cause hæmorrhages from the kidney and pelvis, as well as abscesses.

Both lithæmia and oxaluria are of frequent occurrence, and need not of necessity lead to the production of calculi, though this may occur. Persons so affected will pass large quantities of uric acid or oxalate of lime, or both, and their urine almost invariably has a high specific gravity.

Causes.— The causes of these conditions are practically unknown. It was believed that persons who live high, eat an excessive amount of meat as well as starchy and saccharine substances, and drink considerable champagne, are predisposed to the so-called uric acid diathesis. This is undoubtedly true in some cases; but in others just the opposite conditions prevail, and still uric acid is voided in large amounts.

Clinical Symptoms.— The clinical symptoms in these cases, which are much the same in both conditions, are headache, general malaise, dyspepsia, sleeplessness, neurasthenia, and later on melancholia. Pronounced pain is never present, but there is often a dull, aching feeling in the lumbar region. Persons so affected always sooner or later suffer from neurasthenia and melancholia, and may be treated for a variety of affections before the true cause of their condition is discovered.

LITHÆMIA

The microscopical features in the urinary sediment of a person affected with lithæmia are quite characteristic (Fig. 92).

Crystals of uric acid are found in large numbers, and as a rule all three varieties,— the common form, that seen in over-acid urine, and gravel from the pelvis of the kidney,— are present. The crystals may attain large sizes, but usually the smaller sizes only are met with. Besides these, crystals of oxalate of lime in moderate numbers are also present. In many cases which come under observation, pus-corpuscles are found in small or moderate numbers, as well as different epi-

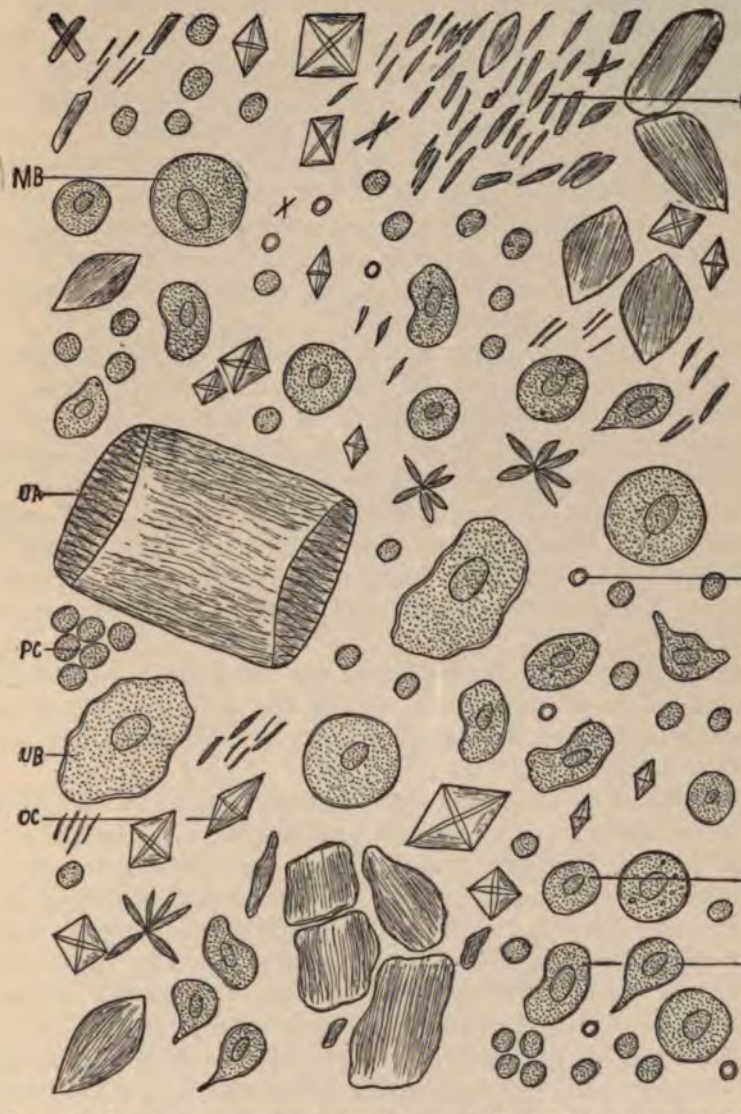

FIG. 92. LITHÆMIA, WITH SUBACUTE CATARRHAL PYELITIS AND CYSTITIS (× 500).

UA, uric acid crystals; OC, oxalate of lime crystals; RB, red blood-corpuscle; PC, pus-corpuscles; PE, epithelia from the pelvis of the kidney; UE, epithelium from the ureter; UB, epithelium from the upper layers of the bladder; MB, epithelium from the middle layers of the bladder.

thelia, more especially those from the pelvis of the kidney and the ureters, though epithelia from the convoluted tubules in small numbers and bladder epithelia are rarely absent. Red blood-corpuscles are not numerous when no hæmorrhage has taken place, though a few are always seen. A few fat-globules are usually seen in the pus-corpuscles and epithelia.

In these, the common cases of lithæmia, we have, therefore, an inflammation of moderate severity only, either a simple pyelitis or a pyelo-nephritis, with an accompanying cystitis. The inflammation, when seen, is rarely acute, but usually subacute or chronic. Such a condition may go on for many years without producing any other features.

When large numbers of these salts are continually produced and deposited in the pelves and calices of the kidneys, smaller or larger concretions or calculi will then be formed, and cause more pronounced symptoms. In such cases, the first symptom is not infrequently a hæmorrhage from the kidney or pelvis, with more or less severe pain. The urine will show all the features of such a hæmorrhage, together with concretions of uric acid. After a day or two all the symptoms may subside, but if the causes leading to the formation of the salts still continue, will recur sooner or later.

Haemorrhage from the Pelvis of the Kidney.—Hæmorrhage from the pelvis of the kidney, due to uric acid calculus, gives characteristic features in the urine, from which the diagnosis can easily be made (Fig. 93).

The field is crowded with red blood-corpuscles, which vary very considerably in shape, size, and appearance. As the urine is usually not examined until a number of hours after it is voided, a comparatively small number will be found containing hæmoglobin, and are therefore of a yellowish or slightly brown color. The larger number usually have lost the hæmoglobin, and these corpuscles will appear colorless, with a distinct double contour. They are found either singly or conglomerated in large groups. Crenated red blood-corpuscles are frequently found, but in small numbers only, and they may also be seen edgewise. When they have imbibed water, they swell up, and may be even double their usual size. Again, a varying number of hæmatoblasts, which present the features of red blood-corpuscles, but are only half their size, are often seen in an active hæmorrhage. White blood-corpuscles, which are twice the size of the fully formed

FIG. 93. HÆMORRHAGE FROM PELVIS OF KIDNEY, DUE TO URIC ACID CALCULUS (500.)

UA, uric acid crystals; RB, red blood-corpuscles; WC, white blood-corpuscle; PE, epithelia from the pelvis of the kidney; UE, epithelium from the ureter; CT, connective-tissue shreds.

red blood-globules, and can not be distinguished from pus-corpuscles, are present in small numbers. They are always granular, either pale with a fine granulation, or more glistening and having a coarser granulation. When comparatively few of these corpuscles are seen, we know that they are not pus-corpuscles, and their presence should never cause the diagnosis of an inflammation.

Besides the blood-corpuscles, uric acid crystals, in the form of irregular plates, masses, and needles, are abundant. They vary considerably in size, are always colored, and may be either single or conglomerated. The needles may be seen in groups containing individual small formations, which sometimes appear like small granules, or they are large and form stellate masses. These are the characteristic forms from the pelvis of the kidney, which, when small, produce gravel; when large, are portions of calculi.

Epithelia from the pelvis of the kidney, varying in size but always characteristic, are more or less numerous. When the hæmorrhage is severe, many fields may sometimes have to be examined before they are discovered, and the place of origin of the hæmorrhage becomes clear; but they are always present, often in groups of three, four, or more. Smaller epithelia from the ureter are also seen. Connective-tissue shreds are never absent, though their number and size may be small. In pronounced cases they are usually found in large numbers.

Besides these features, variously sized masses of fibrin, in the form of thin, pale, often colorless strings, consisting of wavy bands, may sometimes be seen, and irregular clots of blood can also be found. In such hæmorrhages, all the features, including the epithelia and connective-tissue shreds, may occasionally have a yellowish color from the hæmoglobin; but this is not the rule, unless the centrifuge has been used and the examination made immediately after the urine is passed.

Pyelitis Calculosa.—In the so-called pyelitis calculosa, an inflammation or even suppuration of the pelvis is present, and due to calculi, the most common of which are uric acid and oxalate of lime, though phosphatic stones are also not rare. The features are the same as those found in any catarrhal or suppurative pyelitis, with the addition of concretions. Red blood-corpuscles are invariably present in such cases, but, unless a hæmorrhage occurs in the course of the inflammation, never in large numbers.

OXALURIA

Among the anomalies of secretion, oxaluria plays an important part. It is far more common than is generally supposed, and in all cases giving vague neurasthenic symptoms, the urine should be examined. The specific gravity is usually high, not infrequently 1.030 or even 1.040, and the amount of urine passed does not vary much from the normal. The microscope always shows large numbers of crystals of oxalate of lime, in all shapes and sizes, and even in the milder cases an irritation of the pelvis of the kidney is rarely absent, so that a small number of pus-corpuscles and pelvic epithelia is found. Instead of a plain irritation, all the grades of inflammation may at different times exist, though oxaluria alone, without the presence of a stone, will never cause suppuration.

When many crystals are seen, minute concretions, which are so small as to give no special symptoms, are frequently passed, and these, in a few cases, may cause hæmorrhages from the pelvis. In a number of cases, which have come under observation, prolonged hæmaturia existed, and the cause could not be discovered, as there was no pain connected with it, and no reason to suppose the presence of a calculus. Microscopical examination showed those minute concretions, and easily cleared up the case.

HÆMOGLOBINURIA

Hæmoglobinuria is a rare condition, which is characterized by a dissolution of the red blood-corpuscles, and the appearance in the urine of the coloring matters of the blood in solution. The red color of the urine which is always found in these cases is, therefore, not due to the presence of a large number of red blood-corpuscles, as in hæmaturia, but to that of dissolved hæmoglobin.

Causes.—The affection is occasionally seen after poisoning with different substances, such as carbolic acid, sulphuric acid, naphthol, muriatic acid, pyrogallic acid, and even chlorate of potash. It may occur in the course of severe infectious diseases, and is perhaps most common accompanying black vomit in yellow fever. After extensive burns, in scurvy, and purpura it has also been described.

Besides these, it may occur as an idiopathic disease of inter-

mittent character—the paroxysmal hæmoglobinuria,—which is said to sometimes develop in rare cases of syphilis. In such cases urine containing hæmoglobin may be voided either for a few hours only, or more rarely for days or even weeks, accompanying symptoms much like those of intermittent fever. As a rule, attacks of this kind, follow exposure to cold.

Features Found in Urine.—The appearance of the urine in hæmoglobinuria is always dark red or brownish, the sediment being abundant. The specific gravity varies considerably, but, as a rule, is slightly increased. Albumin will be found in varying amount. Although the disease is by no means a distinct kidney affection, changes having taken place in the blood, a nephritis of varying degrees of intensity usually accompanies it, and its features will be found in the urine.

The microscopical elements in a pronounced case of hæmoglobinuria, which occurred in yellow fever, are illustrated in Fig. 94.

The urinary sediment contains an extremely large number of dark or rather rust-brown masses, made up of granular matter, as well as granules scattered irregularly over the field. The masses vary considerably in size, some being small but others large, and may assume different shapes; these are the masses and granules of hæmoglobin.

Hæmoglobin is also found in the form of regular casts, which appear filled with dark brown granules, and differ from blood casts. The latter are rarely absent, though the blood-corpuscles are never found fully formed in the casts, but always disintegrated, and of a rust-brown color. Epithelial casts are frequently present and are also studded with hæmoglobin.

Red blood-corpuscles are never entirely absent in these cases, though they are comparatively scanty, and always, even in the freshly voided urine, appear very pale and double contoured, having completely lost their coloring matter.

Besides these features, pus-corpuscles and epithelia are present, many of which are entirely filled with granules of hæmoglobin and have a dark brown color. Pus-corpuscles are fairly abundant, and epithelia from the convoluted and straight collecting tubules of the kidney in moderate numbers. Epithelia from the ureters and the pelves of the kidneys are constant occurrences.

Connective-tissue shreds are usually found, and may contain

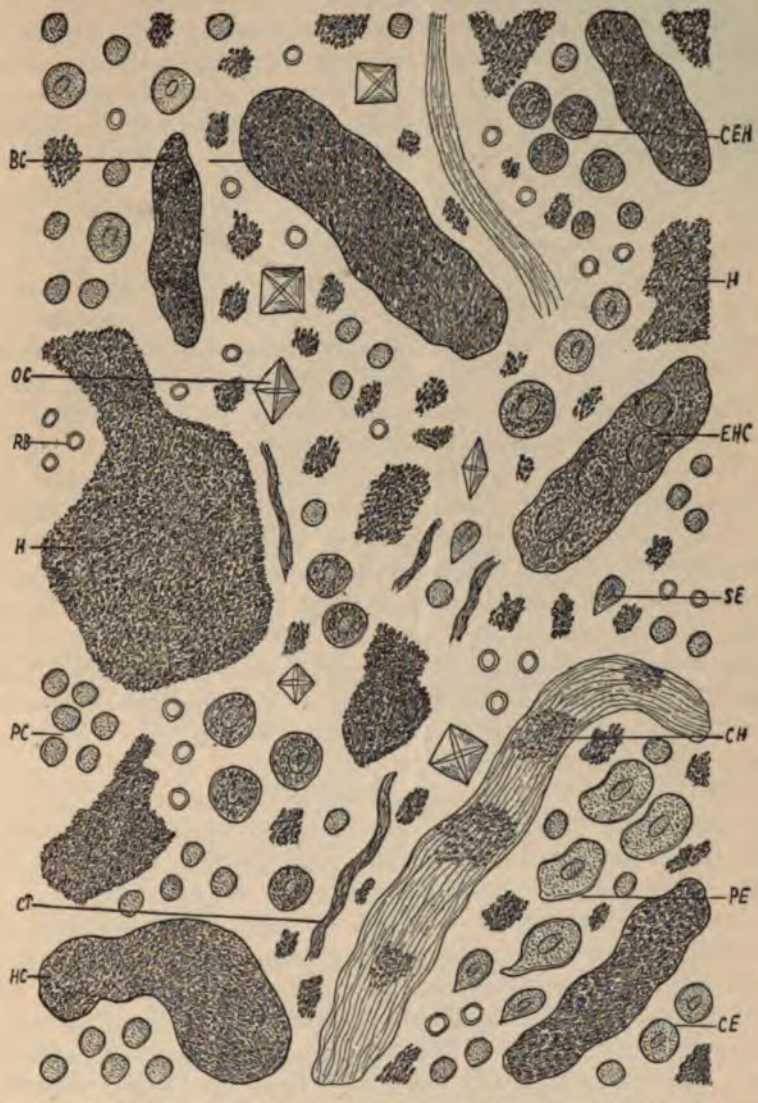

Fig. 94. HÆMOGLOBINURIA, ACUTE HÆMORRHAGIC CROUPOUS OR PARENCHYMATOUS NEPHRITIS WITH CATARRHAL PYELITIS (× 500).

RB, red blood-corpuscles; PC, pus-corpuscle; H, hæmoglobin; CE, epithelia from the convoluted tubules of the kidney; SE, epithelium from the straight collecting tubules of the kidney; CEH, epithelia from the convoluted tubules filled with hæmoglobin; PE, epithelia from the pelvis of the kidney; HC, hæmoglobin cast; BC, blood cast; EHC, epithelial cast filled with hæmoglobin; CT, connective-tissue shred; CH, cylindroid with hæmoglobin; OC, oxalate of lime crystals.

some granules of hæmoglobin upon them. Mucus in the form of threads or casts may be present, studded with masses of hæmoglobin. In most cases different salts, especially crystals of oxalate of lime, and uric acid crystals, are seen. In cases which have lasted a long time needles and plates of hæmatoidin may be found.

CHYLURIA

Chyluria is characterized by the milky white appearance of the urine, similar to milk or to chyle; this appearance it retains on account of the molecular division of the fat which it contains, even if left standing for days. In some cases, though not in all, chylous urine has a pink tinge, due to the red blood-corpuscles frequently present.

Two varieties of the affection are recognized: the first, or tropical form, occurs almost exclusively in hot climates, and is due to an invasion of the blood and urinary tract by a parasite—the *Filaria sanguinis hominis;* the second, or non-tropical form, is not due to a parasite, and is so rare that but little is known about it.

In most cases chylous urine contains coagula, due to a large amount of fibrin, which is usually present. These clots form in the bladder, and may be so abundant as to give rise to distressing symptoms when voided.

The features of a chylous urine are illustrated in Fig. 95. The case from which the illustration was drawn was recently seen by the author, and occurred in the practice of Dr. T. H. Allen, of New York. Its brief history is the following:

Man, 33 years of age, a native of Porto Rico, has lived in the United States for nine years. Three years ago he went to his native country for two weeks and then returned to the United States. Two months after returning, he noticed a milky appearance of his urine. The urine cleared up after a short time, and remained clear for more than two years, when it again became milky. The only symptoms he complained of, when he first came under observation, were pain in the back and a slight frontal headache. In appearance, the patient was thin and delicate looking. Upon physical examination nothing could be discovered except a slightly enlarged liver.

Features Found in Urine.—The appearance of the urine

FIG. 95. CHYLURIA, CATARRHAL CYSTITIS (× 500).

FG, free fat-globules; RB, red blood-corpuscles; F, fibrin, with red blood-corpuscles and hæmatoidin-crystals; FS, Filaria sanguinis; PC, pus-corpuscle; UE, epithelium from the ureter; MB, epithelia from the middle layers of the bladder; CT, connective-tissue shred.

was that of milk, in which slightly colored, pink coagula were suspended. The clots were numerous and greatly varied in size, the largest being removed from the bottle with difficulty. They had various shapes, some resembling cysts. The specific gravity was 1.015, the reaction slightly acid, and the urine contained one-half of 1 per cent of albumin.

Under the microscope the clots proved to be masses of fibrin, imbedded in which large numbers of red blood-corpuscles were found, and in a few also small plates of hæmatoidin. In every field not obscured by the fibrin, red blood-corpuscles were very abundant, lying in groups, as well as singly, partly of a yellowish color, containing hæmaglobin, and partly colorless. Crenated red blood-corpuscles were present in moderate numbers, and many were seen edgewise.

Besides these, minute fat-globules and -granules were extremely numerous, partly in smaller or larger masses, partly lying irregularly throughout the field. Nowhere could larger fat-globules be seen. In some of the drops examined, a number of parasites, the embryonal forms of the *Filaria sanguinis*, could easily be discovered; they were of different sizes. In one drop, a group of five, imbedded in, or perhaps surrounded by, a mass of fat-globules, was found. One small body, apparently an ovum, was also seen.

The other features were pus-corpuscles and epithelia from the ureters and the middle layers of the bladder. Neither the pus-corpuscles nor the epithelia were found in every drop, it being necessary to examine a number of drops before they were seen. Connective-tissue shreds were present, though not in every drop. No salts whatever could be discovered under the microscope.

III. *MALIGNANT TUMORS OF THE KIDNEY*

Malignant tumors of the kidney are fortunately rare, but do occur, and both sarcomata and carcinomata are met with. The former may be found at all ages, while the latter, which in the kidneys seem to be of still rarer occurrence than sarcomata, are usually seen in persons more advanced in years. The diagnosis of sarcoma of the kidney can be positively made from the examination of the urine, while that of cancer might perhaps be suspected, but can hardly be made with the same degree of certainty as when it occurs in the bladder.

Clinical Symptoms.—When a malignant tumor has lasted for some time, the clinical features will become pronounced enough to at least suspect its presence, but in the early stages its symptoms are not well defined; though even at this time characteristic features may be found in the urine. Pain, referred either to the region of the affected kidney, or, less clearly defined, radiating to neighboring organs, will usually be the earliest symptom. It is mostly of a severe character, and may be paroxysmally increased.

Very soon a tumor in the region of the kidney can be mapped out, the patient becomes anæmic and cachectic, and gradually loses strength. If not relieved by surgical procedures, the general symptoms become more pronounced, and the disease, as a rule, ends fatally within one or two years, although cases of sarcoma which have lasted four or five years are on record.

Appearance of Urine.—The appearance of the urine is not characteristic. Since symptoms of inflammation soon develop, the specific gravity, color, and amount of urine voided will vary with the intensity of the inflammation. Hæmorrhages, either constant or recurring at irregular intervals, soon appear, and the urine then has the pronounced reddish or brown color, due to the blood. Albumin is always present in varying amount.

SARCOMA.

Sarcoma of the kidney may be found in children as well as in adults, the youngest case seen by the author and diagnosed from the urine having been in a boy of four years, the oldest in a man of sixty-five years. Although the macroscopical appearance of the urine may vary considerably, the microscopical features are usually characteristic enough to admit of a positive diagnosis. In two cases the examination of the urine gave the first evidence of the disease, the clinical symptoms of the patient not being at first clear; by careful examination of the patient, however, a tumor of the kidney could soon be mapped out, and further developments proved the correctness of the diagnosis.

Features Found in Urine.—That sarcoma of the kidney can be diagnosed from the urine was first shown by Carl Heitzmann, and a number of cases were published by him in the year 1888. Since then other cases have been seen by the author, and autopsies have left no doubt of the correctness of his asser-

abundant. Epithelia from the pelvis of the kidney could be seen, and in many of them the endogenous new-formation of pus-corpuscles, indicating pressure, were present. Epithelia from the ureter and the middle layers of the bladder completed the features.

Not infrequently a croupous nephritis may be present, and then casts, especially of the granular and fatty variety, will be found.

CANCER

In cancer of the kidney, a positive diagnosis can not be made so easily from the simple examination of the urine. When a large number of irregular connective-tissue shreds, containing inflammatory corpuscles, and perhaps also larger, coarsely granular, frequently multi-nuclear epithelia are found, together with all the evidences of a chronic inflammation, cancer can undoubtedly be suspected, and the clinical symptoms will soon clear up the diagnosis. In rare cases, we may find regular cancer nests, similar to those described in cancer of the bladder.

Chapter XV

DISEASES OF THE BLADDER

I. *INFLAMMATIONS OF THE BLADDER*

According to the degrees of intensity, inflammation of the bladder—cystitis—may be divided into catarrhal, suppurative, and ulcerative. The inflammation may be either acute, subacute, or chronic, and may affect either small portions of the mucous membrane of the bladder only, or almost the whole.

The pathological changes in catarrhal inflammation of the bladder are the same as those found in any mucous membrane, and have been described in the previous chapter. In severe inflammations ulcers may be formed, which may become quite extensive, and in rare cases even lead to perforation. Occasionally abscesses will form in the wall of the bladder.

Causes.— The causes of a cystitis, which may be either primary or secondary, are numerous. Primary cystitis may be due either to exposure to cold, to chemical irritation, or to traumata. That a simple exposure to cold may cause a cystitis, often quite severe in character, can not be denied. Among the chemical irritants different remedial agents, such as turpentine, copaiba, cantharides, and strong mineral acids, may be mentioned. Alcoholic stimulants in large amount may cause mild attacks, as well as certain articles of diet, such as asparagus.

One of the most common causes of cystitis is the passage into the bladder of instruments, such as catheters or sounds, which have not been thoroughly disinfected, so that pyogenic bacteria are introduced in large numbers. Again, traumata of different kinds are often responsible for the development of a cystitis.

Secondary cystitis is at least as frequent as the primary form, and is often due to an extension of the inflammatory process from one or other of the genito-urinary organs. Gonorrhœa is a common cause of cystitis, in the first days of the disease as well as later on. Prostatitis, hypertrophy of the prostate gland, semi-

nal vesiculitis, vaginitis, cervicitis, and parametritis, as well as perimetritis, may all cause it. Again, inflammations of the bladder may be produced by an inflammation of the kidney, pelvis, and ureter, the process gradually extending downward. Indeed, it is rare that a secondary cystitis, though mild in character, does not accompany a nephritis or pyelo-nephritis, even in acute cases. In chronic cases, such an accompanying inflammation is always present.

That other affections of the bladder, such as tumors or calculi in the bladder, will soon cause an inflammation, is evident. In many other diseases, such as the different infectious and contagious diseases, it may occur at any time. Retention of the urine must be looked upon as an important cause.

In many cases, but not in all, micro-organisms in varying numbers will be present. In the mild acute cases, they may be absent entirely, or be present in small numbers only, while in the more pronounced cases they are always numerous. As a rule, both cocci and bacilli are found, though one or the other may predominate or even exist alone. The varieties of the micro-organisms which may be present in the bladder can not always be determined, since a number will undoubtedly be of secondary origin. Among the cocci, the different staphylococci—staphylococcus pyogenes aureus, albus, and citreus—as well as the streptococci pyogenes are common. The micrococcus ureæ is often found in large numbers, and a variety of sarcina, called sarcina urinæ, somewhat smaller than the usual form, is not rarely seen.

Among the bacilli, the bacterium coli commune, the bacillus ureæ, and the urobacillus liquefaciens septicus, occur. In some cases leptothrix threads are abundant. It has been claimed that the bacterium coli commune is more frequently found in cystitis than any other one bacillus, though the number of bacilli described is quite large.

In the cases of so-called bacteriuria, bacteria of various forms may be present in enormous numbers in the bladder, and their origin can not always be determined. It is certain that bacteria alone will not cause cystitis, but when an irritation of some kind exists, they can set up a severe inflammation. The reaction of the urine does not necessarily need to be alkaline when micro-organisms have developed; but on the contrary, some, as the bacterium coli commune, are frequently found with an acid reaction.

Clinical Symptoms.—The symptoms seen in cystitis vary considerably with the severity and acuteness of the attack. An intense acute inflammation may be ushered in by chills, followed by moderately high fever, and all the concomitant symptoms of the same. In milder cases, fever will not be present. Frequent micturition invariably exists; this varies considerably with the intensity of the inflammation, and in the severe cases there is a constant desire to urinate, although only a few drops may be voided at a time. More or less intense pain is never absent. The pain may be most pronounced at or just before the beginning of micturition, be somewhat diminished during the flow of urine, and again become more severe at the end of micturition. At other times the flow of urine seems to increase the pain, which is diminished immediately after. A certain amount of pain or discomfort almost invariably exists irrespective of urination, and may radiate to the back, thighs, scrotum, and penis. It may be most severe in the perinæum. Pressure upon the bladder, as well as the passage of a catheter or other instrument, always causes more suffering.

In chronic cases which are comparatively mild in character, frequent micturition, sometimes not very pronounced, with a feeling of discomfort, may be the only symptom. When a cystitis has lasted for a long time the bladder becomes enlarged, sometimes to a great degree. In such cases, the bladder is never entirely emptied, and incontinence may exist, so that the urine will dribble away continually.

Appearance of Urine.—The appearance of the urine varies. In the mild cases, when no bacteria are present, it may be perfectly transparent, but as soon as bacteria in moderate or large numbers have developed it is more or less turbid. The specific gravity also differs, being normal in mild cases and increased or diminished in the severer forms. Albumin is never entirely absent in these cases, since it will always be found whenever pus-corpuscles are seen in the urine. In mild cases, however, no more than a trace, sometimes very faint, can be discovered, while in the more intense cases it may exist in large amount. The reaction of the urine may be acid or alkaline. In mild acute cystitis, even when a few bacteria are seen, it may be acid, though, as a rule, only slightly so. In chronic cases, on the other hand, the urine is always more or less alkaline, and the alkalinity may be marked.

CATARRHAL CYSTITIS

Microscopical Features.—The microscopical features in cystitis differ in the acute and chronic cases, as well as with the intensity of the inflammation, and are always characteristic on account of the presence of bladder epithelia. Pus-corpuscles, epithelia from the bladder, and mucus-threads are never absent, though their amount differs in the different cases.

Acute Catarrhal Cystitis (Fig. 97).—In an acute catarrhal cystitis of moderate severity the reaction of the urine may still be slightly acid, and salts will usually be found under the microscope, though they are not abundant. Those most commonly seen are crystals of oxalate of lime of different sizes, present in almost every field. Even in these cases, however, which still give an acid reaction, a small number of globules of urate of ammonium, partly the dumb-bell form of urate of ammonium in *statu nascenti*, partly small, but fully formed globules, are seen.

Pus-corpuscles are never absent, as without them, no diagnosis of inflammation is possible; but their number varies, and the mildest cases show perhaps only two, three, or four in every field. The more intense the inflammation, the more numerous are the pus-corpuscles. Red blood-corpuscles are present in every case of acute cystitis, and also vary in number to a great degree; but unless hæmorrhages have occurred, are never abundant. In hæmorrhages, which are rare, and usually found only when the cystitis is due to calculi, tumors, parasites, or a severe trauma, the red blood-corpuscles may be so abundant as to obscure the other features.

The diagnosis of a cystitis depends entirely upon the presence of the characteristic epithelia from the different layers of the bladder. As previously explained, the bladder has stratified epithelium, the different strata of which contain different epithelia. The upper layers are lined with flat, the middle with cuboidal, and the deepest covering, one layer only, with columnar epithelia. The flat epithelia are desquamated in perfect health, though to a small degree only, and when these are present alone in the urine, without any pus-corpuscles or cuboidal epithelia, the diagnosis of cystitis must never be made. As soon as the cuboidal epithelia are found, we can be certain of a pathological process in the bladder; the more pronounced, the more numerous they are.

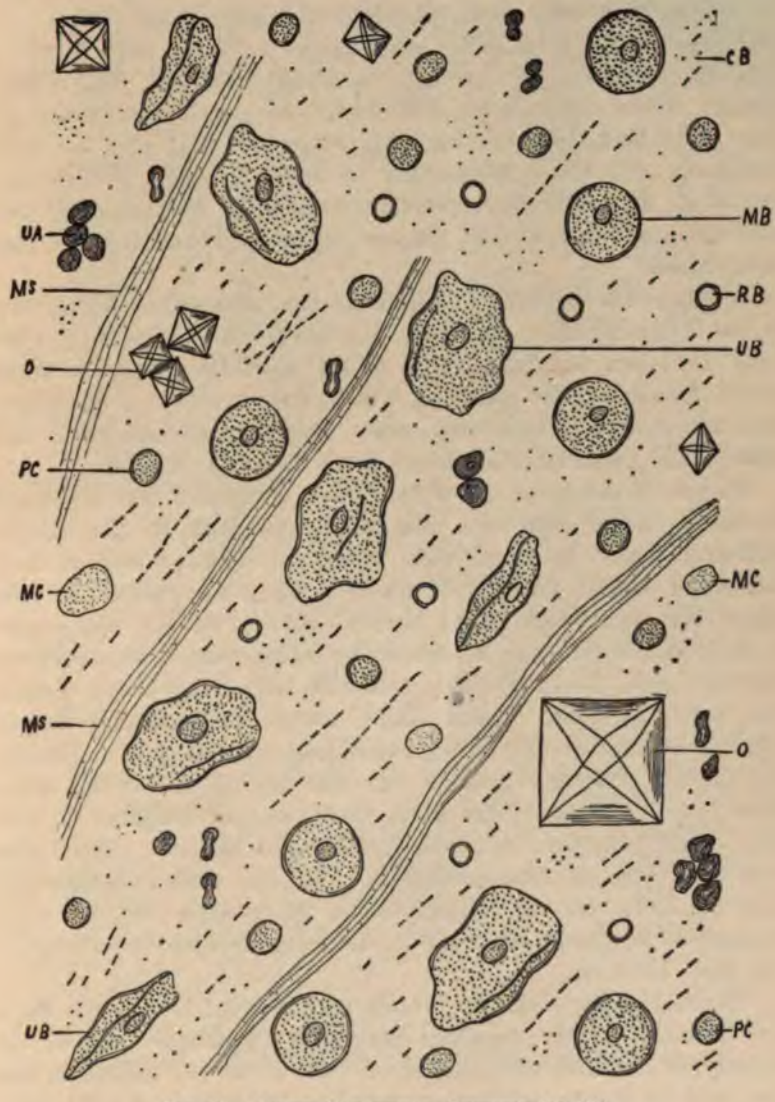

FIG 97. ACUTE CATARRHAL CYSTITIS (× 500).

RB, red blood-corpuscles; PC, pus-corpuscles; O, oxalate of lime; UA, urate of ammonium; UB, epithelia from the upper layers of the bladder; MB, epithelia from the middle layers of the bladder; MS, mucus-threads; MC, mucus-corpuscles; CB, bacilli and cocci.

In an acute catarrhal cystitis, the flat epithelia from the upper layers and the cuboidal from the middle layers are always present together, and the more flat epithelia we find in comparison with the cuboidal, the milder the case. In such cases pus-corpuscles are scanty. When the flat and cuboidal epithelia are present in equal numbers, the inflammation is not very severe, but when the cuboidal epithelia are more abundant than the flat, pus-corpuscles will also be more numerous and the inflammation is more intense. We do not expect to find columnar epithelia, unless the inflammatory process has extended to the deepest layer, and has become very pronounced.

The sizes of the different epithelia vary in a small degree only in the different cases, therefore can always be diagnosed. Care must be taken not to mistake folded epithelia from the upper layers for columnar epithelia, which they sometimes resemble; they are, however, somewhat more irregular, always paler, and more finely granular than those from the deepest layer.

Mucus in the form of threads and corpuscles can be found in almost every case, and are more abundant in the severer inflammations. Mucus-threads are pale, and consist of fine, sometimes hardly perceptible fibers. They can never be mistaken for connective-tissue shreds—which we do not expect to find unless the case is intense or hæmorrhages occur,—since they are pale, finely striated, and the individual fibers usually run quite parallel. When large, mucus-threads may branch off and sometimes fill the greater part of the field. Besides the threads, mucus-corpuscles are also found in varying numbers. Such corpuscles are pale, more or less irregular in outline, finely granular, and never contain a nucleus. They may have the size of pus-corpuscles, but are often considerably larger. Even in the milder cases of cystitis the so-called cylindroids or mucus-casts—pale, delicate, striated formations,—can also be seen.

The only other features which may be found in these cases are bacteria. Their number has little significance as to the severity of the inflammation, since even in severe inflammations they may be scanty, while they may be abundant in a mild case.

Chronic Catarrhal Cystitis (Fig. 98).—In chronic catarrhal cystitis the reaction of the urine is usually alkaline, and the more pronounced it is, the more chronic is the case. The sedi-

FIG. 98. CHRONIC CATARRHAL CYSTITIS (× 500).

UA, urate of ammonium; TP, triple phosphates; SP, simple phosphates; PC, pus-corpuscles; MB, epithelia from the middle layers of the bladder, containing fat-globules; MS, mucus-threads; MC, mucus-corpuscles; BC, bacilli and cocci; FG, free fat-globules.

ment generally contains the different varieties of phosphates, both complete and incomplete triple, as well as star-shaped simple phosphates. Globules of urate of ammonium are often quite abundant.

Pus-corpuscles vary in number according to the intensity of the inflammation, and in many small, glistening fat-granules and -globules will be found. Sometimes they contain dark brown granules of pigment. In the more intense cases, pus-corpuscles are numerous and are frequently swollen, hydropic, or disintegrated. In purely chronic cases, red blood-corpuscles are scanty or entirely absent. When acute recurrences or hæmorrhages ensue, they become considerably more numerous.

Epithelia are always present in greater or less amount, but their relative numbers are somewhat different from those found in acute cystitis. While in the latter flat epithelia from the upper layers are quite abundant, they are either entirely absent in the chronic cases, or are seen in small numbers only; this is one of the differential points of diagnosis. Epithelia from the upper layers, when present in large numbers, denote either an acute case, or an acute recurrence of a chronic inflammation. Cuboidal epithelia from the middle layers are always found in varying numbers, many containing fat-granules or -globules. Columnar epithelia from the deepest layer are seen in the severer cases only, and then in small numbers. Free fat-globules are always present.

Mucus-threads and -corpuscles are constant features in chronic catarrhal cystitis. In cases having a highly alkaline reaction, the urine is ropy and a jelly-like, viscid mass is present, sometimes so pronounced as to compose the greater part of the sediment. A urine containing such masses always has an ammoniacal odor, and the alkaline salts are extremely numerous. Besides the salts and bacteria, such a jelly-like mass consists of strings of mucus, sometimes filling entire fields of the microscope. In many of these cases, neither pus-corpuscles nor epithelia can be recognized to any great degree, having become hydropic, pale, and apparently changed to mucus-corpuscles. The appearance of a urine containing such masses is so characteristic to the naked eye that a diagnosis of chronic cystitis can, in many cases, be made without a microscopical examination. Bacteria are never absent in chronic inflammations, and are usually abundant.

Subacute Catarrhal Cystitis.— The features found in a subacute catarrhal cystitis are a moderate number of red blood-corpuscles, pus-corpuscles, as a rule not abundant, a few epithelia from the upper layers of the bladder, a moderate number from the middle layers, a few fat-globules, and a moderate amount of mucus. The reaction, in such cases, is usually slightly alkaline.

ULCERATIVE CYSTITIS.

The development of ulcers in the bladder is not rare, and traumata of different kinds are perhaps the most frequent causes. With the presence of calculi and parasites in the bladder, but especially tuberculosis in any part of the genito-urinary tract, ulcerative cystitis is of common occurrence. In pronounced cases, such a urine has an intensely putrescent odor, and is very turbid.

Microscopical Features—**Acute Ulcerative Cystitis** (Fig. 99). Under the microscope the features of an acute ulcerative cystitis are the following:

The number of pus-corpuscles varies considerably, and they are not necessarily abundant. Red blood-corpuscles are always fairly numerous, and in many cases regular hæmorrhages exist. Epithelia from the bladder are abundant, and present from all three layers; the columnar epithelia from the deepest layer, usually absent in catarrhal inflammation, are often just as abundant as those from the middle layers.

Connective-tissue shreds are found in large numbers, some of the shreds being large, while others are only of small size. These shreds are highly refractive, and consist of wavy, irregular fibers. The difference between them and mucus-threads, which are also present in varying numbers and are much paler than the former, is plain.

Bacteria are numerous in all these cases, and zoöglœa masses are invariably found. These masses are often large and numerous, and are never seen to such an extent in simple catarrhal cystitis. Their diagnosis is easy, and when large groups are present around connective-tissue shreds, in fresh urine, the existence of an ulcer is almost certain. The salts vary considerably in amount in acute cases, and at times they are found in small numbers only.

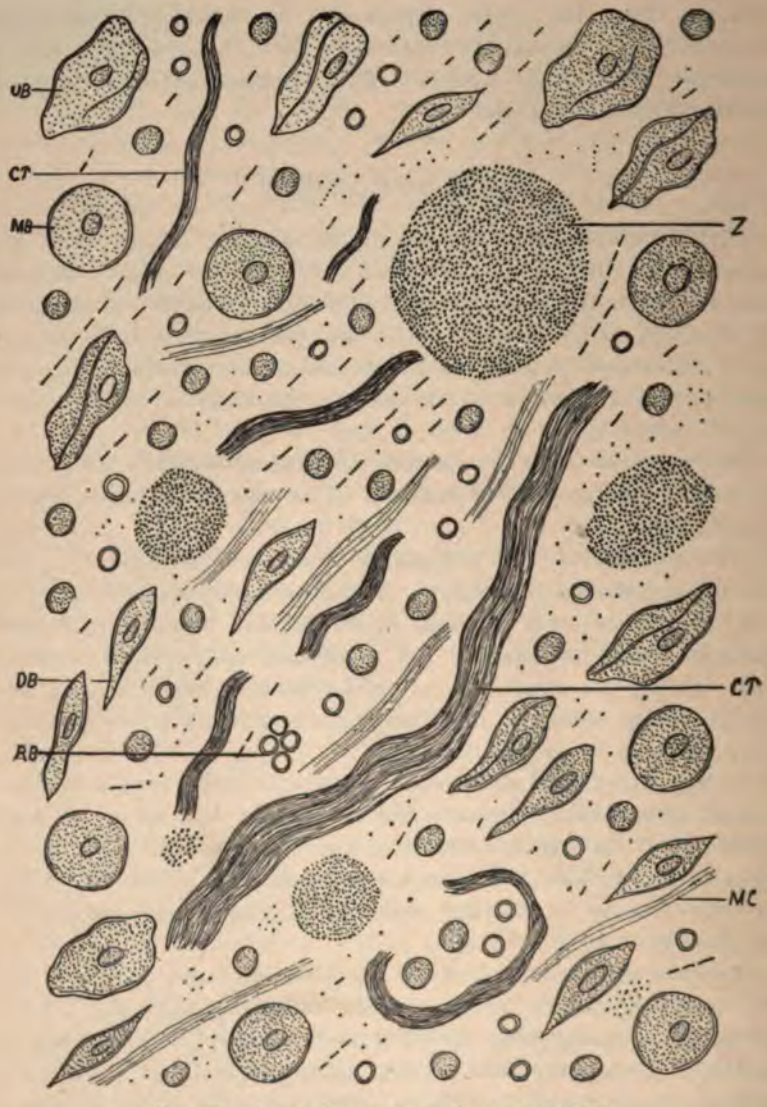

FIG. 99. ACUTE ULCERATIVE CYSTITIS (× 500).

RB, red blood-corpuscles; PC, pus-corpuscles; UB, epithelia from the upper layers of the bladder; MB, epithelia from the middle layers of the bladder; DB, epithelia from the deepest layer of the bladder; CT, connective-tissue shreds; MC, mucus-threads; Z, zoöglœa-masses.

Chronic Ulcerative Cystitis (Fig. 100).—Alkaline salts, especially phosphates, are abundant. Pus-corpuscles are present in moderate number, but red blood-corpuscles are usually scanty. Epithelia from the upper layers of the bladder are either entirely absent or scanty, though transitional epithelia may be found. Cuboidal and columnar epithelia are abundant, the latter being often quite as numerous as the former. Fat-globules and -granules, both in free groups and in the pus-corpuscles and epithelia, are always seen. Connective-tissue shreds are just as abundant as in acute cases, while mucus-threads and -corpuscles are more numerous. Zoöglœa masses are never absent, and may attain large sizes. Other bacteria are also found in large numbers.

When the diagnosis of a chronic ulcerative cystitis has become clear from the above features, and the constitution is greatly impaired, as seen by the finely granular pus-corpuscles; when, furthermore, no evidences of calculi or parasites are found, an examination for tubercle bacilli should always be made. In a number of cases, where the clinical symptoms were vague, but an ulcerative cystitis was present, examination for tubercle bacilli revealed the existence of a tuberculosis in the urinary tract, and at once cleared up the case.

In one case, which was examined by the author, the ulcerative cystitis was produced by actinomyces. The urine contained a number of small granular masses, apparent to the naked eye, and upon examination these were found to consist of the characteristic club-shaped conglomerations of actinomyces, previously described.

SUPPURATIVE CYSTITIS.

Suppurative cystitis is comparatively rare. The diagnosis can be made if pus-corpuscles are numerous and epithelia from the different layers of the bladder abundant. Connective-tissue shreds are always present and red blood-corpuscles quite numerous. In such cases, bacteria will be seen in larger numbers, but the zoöglœa masses, which are found in every case of ulcerative cystitis, are not present, or, if so, not pronounced. The differential diagnosis between an abscess and an ulcer must, however, be made chiefly from the comparative numbers of pus-corpuscles, which in an abscess are considerably more abundant.

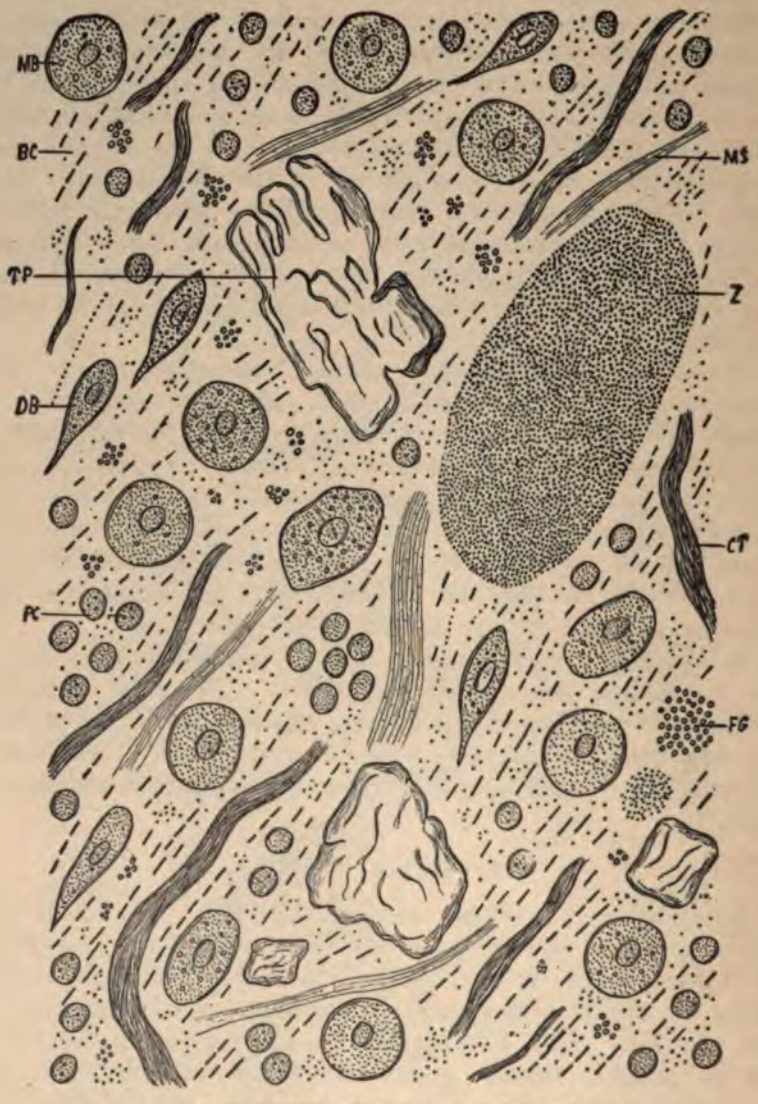

FIG. 100. CHRONIC ULCERATIVE CYSTITIS (× 500).

PC, pus-corpuscles, some containing fat-globules; MB, epithelia from the middle layers of the bladder, some containing fat-globules; DB, epithelia from the deepest layer of the bladder; TP, incomplete triple phosphate; CT, connective-tissue shreds; MS, mucus-threads; FG, free fat-globules; Z, zoöglœa mass; BC, bacilli and cocci.

PERICYSTITIS

When an inflammation is present around the bladder, instead of in the wall of the bladder proper, and pressure is exerted upon that organ, the epithelia from the middle layers of the bladder will show changes in a pronounced degree, which have been previously alluded to as endogenous new-formations. Such changes will occur when parametritic exudates exist, pressing upon the bladder, when a tumor is present either in the neighborhood of the bladder or in the wall of the bladder, or even simple extravasations of blood in the wall of the bladder may cause them. Pressure of any kind, no matter how slight, if continued for some time, such as pressure of the uterus upon the bladder, or of the prostate gland on account of hypertrophy of that organ, or inflammations of the seminal vesicles, will all produce such changes.

In simple catarrhal cystitis a small number of epithelia from the middle layers may be found, containing a number of nuclei or even newly formed pus-corpuscles. So long as these formations are scanty, they may be produced by the inflammatory process alone, a fact which has been known for many years. As soon, however, as the epithelia become irritated through pressure of some kind, the endogenous new-formation of pus-corpuscles in the desquamated cuboidal or columnar epithelia is very abundant. One epithelium may contain from two to four or even six such pus-corpuscles, or, instead of them, vacuoles may be seen, or pus-corpuscles and vacuoles in varying numbers.

The features found in a case of pericystitis due to a parametritis are shown in Fig. 101. They are the following:

Pus-corpuscles are present in rather large numbers, and red blood-corpuscles are fairly numerous. Cuboidal epithelia from the middle layers of the bladder are abundant, and in every one the endogenous new-formation is plainly visible; smaller cuboidal epithelia from the ureters are present in moderate numbers, some of which also contain endogenous new-formations. In a few of the pus-corpuscles and epithelia fat-globules are seen, and small groups of free fat-globules are also found. Mucus-threads are abundant and large, while connective-tissue shreds are scanty and small.

Besides these features, ciliated columnar epithelia from the mucosa of the uterus and larger irregular epithelia from the

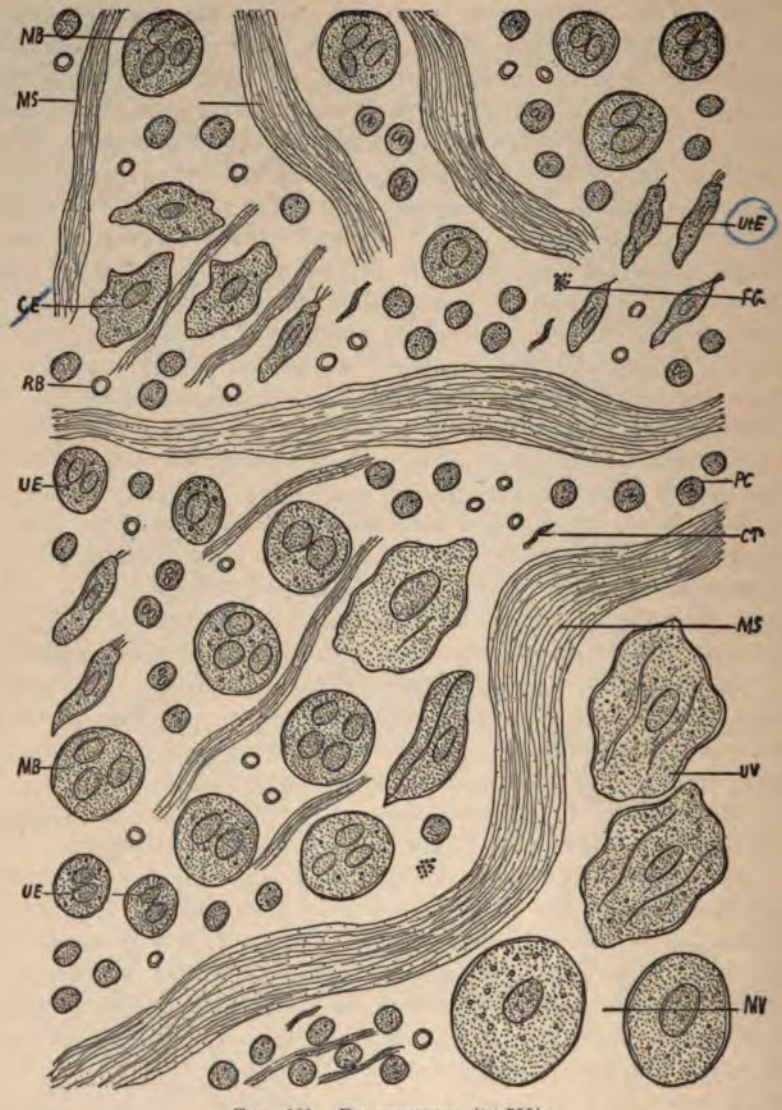

FIG. 101. PERICYSTITIS (× 500).

RB, red blood-corpuscles; PC, pus-corpuscles; MB, epithelia from the middle layers of the bladder, with endogenous new-formations; UE, epithelia from the ureter, with endogenous new-formations; UtE, epithelia from the mucosa uteri; CE, epithelia from the cervix uteri; UV, epithelia from the upper layers of the vagina; MV, epithelia from the middle layers of the vagina; MS, mucus-threads; CT, connective-tissue shred; FG, free fat-globules.

cervix uteri are seen, as well as those from the upper and middle layers of the vagina, which, with the pus-corpuscles, are sufficient evidences of an endometritis, cervicitis, and vaginitis.

II. *TUMORS OF THE BLADDER*

Although many different varieties of tumors may occur in the bladder, the most common, and those which can frequently be diagnosed from an examination of the urine, are benign papilloma and malignant sarcoma and cancer. Myoma is a rare tumor in the bladder, but when present can also be diagnosed, if particles of the tumor appear in the urine. As long as no ulceration has taken place, the presence of a tumor of any kind can only be suspected; but as soon as ulceration has set in and particles of the tumor are found in the urinary sediment, the diagnosis becomes positive.

Clinical Symptoms.—In all tumors of the bladder, benign as well as malignant, one of the first, if not the first, and most pronounced symptoms is hæmaturia, mild in character only at the commencement, and occurring at long intervals, but later becoming more pronounced and more frequent. This hæmaturia may take place at any time, and is just as common during rest as when the patient is active. Besides the hæmaturia, pain is present in many cases, but not in all, being more frequent in malignant than in benign tumors, and radiating to the perinæum, the thighs, and the scrotum. In benign growths, pain, if present at all, is rarely pronounced. Frequent micturition may exist quite early in the disease, and becomes more pronounced in the later stages.

Malignant tumors sooner or later will cause general symptoms, and, as a rule, end fatally in the course of one or two years, although cases of undoubted sarcomata have been known to last for four or five years.

None of the symptoms here given are at all characteristic, and microscopical examination of the urine must be relied upon for a positive diagnosis. Tumors of the bladder may occur at all ages, a case of papilloma having been diagnosed by the author from the urine of a child of one year.

PAPILLOMA

Microscopical Features.—The microscopical features in a case of papilloma of the bladder are illustrated in Fig. 102.

Since hæmorrhage is of such common occurrence in these tumors, red blood-corpuscles are usually present in the urinary sediment in large numbers. These may be irregularly scattered throughout the field, or are found conglomerated in groups, partly yellowish, containing hæmoglobin, but at the time of examination mostly colorless, with the characteristic double contours. In cases of active hæmorrhages, hæmatoblasts, having the appearance of red blood-corpuscles, but only half their size, may be abundant. If the latter contain hæmoglobin, so that the double contour is not seen, care must be exercised not to mistake them for fat-globules, or even conidia; they may be found in large groups as well as singly, between the regular-sized blood-corpuscles.

The characteristic features of a papilloma are peculiar connective-tissue shreds, which, as a rule, are abundant. Although variously sized shreds, not differing in any respect from those generally seen in the urine, are present, the larger numbers have an entirely different appearance. They are long, or extremely irregular, frequently branching in different directions, and often assume the shape of coils or knobs. Such shreds are coarsely granular, and not infrequently contain a number of inflammatory corpuscles. Again they may be found studded with fat-globules of different sizes, some of these being quite large. In rare cases, blood-vessels, either in process of formation or fully formed, some of considerable size, may be contained in them.

The forms in which connective-tissue shreds may be found in the urine when a papilloma exists are sometimes so peculiar that a diagnosis can only be made when smaller and more regular shreds are found. In one case, it seemed at first glance as if large parasites of an unknown nature were present, but a more careful examination showed large knobs and coils, in which capillary blood-vessels, filled with blood-corpuscles, were seen coursing in various directions. The individual fibers of such shreds may have entirely disappeared, and the whole shred appears as a mass of coarsely granular protoplasm; these shreds might well be termed protoplasmic outgrowths of connective tissue. The more common varieties of connective-tissue shreds found in papilloma are shown in the illustration.

In all cases of papilloma, epithelia from the different layers of the bladder, more especially the cuboidal and columnar varieties, are quite abundant, and usually are more or less studded with fat-

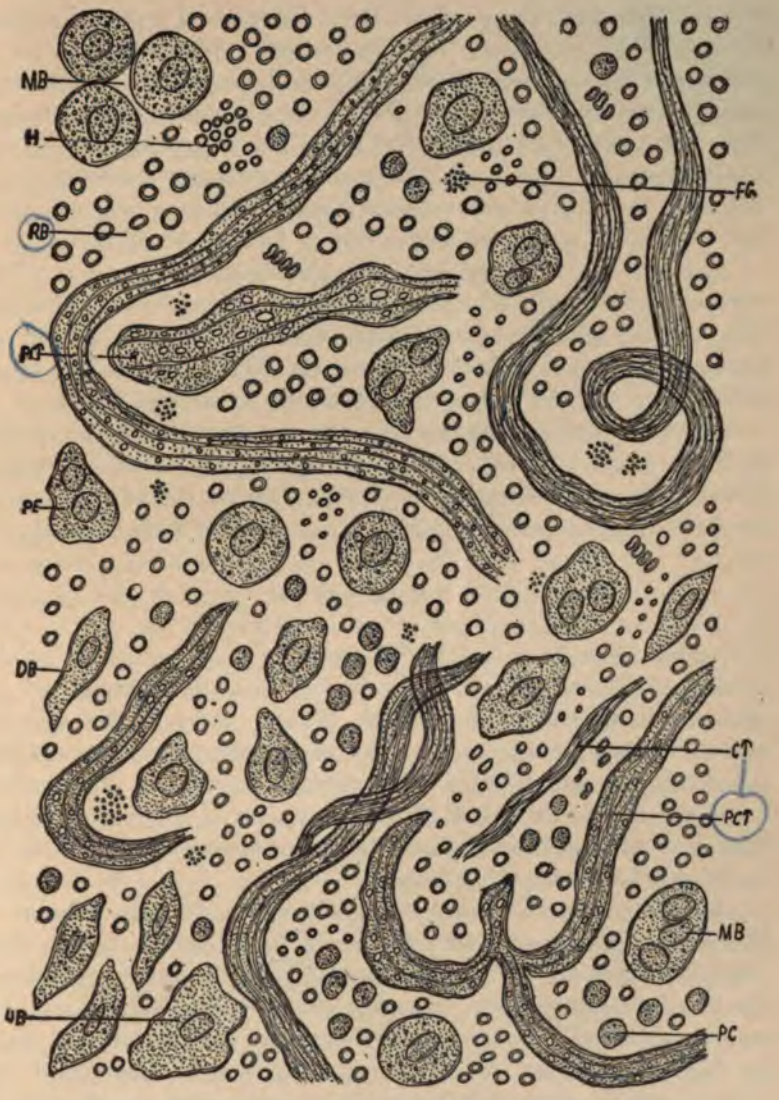

FIG. 102. HÆMORRHAGE FROM THE BLADDER, DUE TO PAPILLOMA OF BLADDER (× 500).

RB, red blood-corpuscles; H, hæmatoblasts; PC, pus-corpuscles; MB, epithelia from the middle layers of the bladder, containing fat-globules; DB, epithelia from the deepest layer of the bladder; PE, covering epithelia of papilloma; UB, epithelium from the upper layers of the bladder; PCT, connective-tissue shreds from papilloma; CT, connective-tissue shred; FG, free fat-globules.

globules, which latter are also seen in small groups. Many of the bladder epithelia contain the endogenous new-formations. Besides these, irregular, coarsely granular epithelia, with endogenous new-formations—the covering epithelia of the papilloma,—are also present. These have the size of bladder epithelia, though they are always irregular, and are not characteristic of the papilloma. In none of the cases were the epithelia found adherent to the connective-tissue shreds, and care must be taken not to attempt a diagnosis of a tumor from these epithelia alone.

In every case of papilloma, pus-corpuscles are present. They vary in amount with the intensity of the accompanying inflammation, which, though never absent, differs in degree in different cases. As a rule, the pus-corpuscles have a moderately coarse granulation, if the tumor has remained local, and produced no secondary nephritis, showing that the constitution of the patient is fairly good. In rare cases, enormous masses of fibrin are found in the urine—regular fibrinuria. Mucus-threads are always present, though the other features may render them indistinct.

SARCOMA

As has been described in the previous chapter, a sarcoma can be diagnosed from the urine, when present in any part of the genito-urinary tract. Sarcomata of the bladder, although not common, undoubtedly occur. As in all tumors of the bladder, hæmorrhages are frequent in sarcoma, and when the urine is examined during an attack of hæmorrhage, the diagnosis becomes more difficult, since no such characteristic connective-tissue shreds as in papilloma are here found.

Microscopical Features.—If blood-corpuscles are present in moderate numbers only at the time of the examination, the other features are distinct enough, and groups of small, glistening, frequently homogeneous, non-nucleated corpuscles, larger than red blood-corpuscles, but smaller than pus-corpuscles, are found in large numbers. These corpuscles, resembling lymph-corpuscles, are the elements characteristic of a small, round-celled or lympho-sarcoma. Connective-tissue shreds must, however, always be seen before the diagnosis becomes positive; these shreds may attain large size, and frequently contain inflammatory corpuscles. In most cases they do not differ from the shreds commonly found in urine, except by their large size.

The other features seen in a sarcoma of the bladder are the same as those seen in every severe subacute or chronic catarrhal or ulcerative cystitis, epithelia from the deepest layer of the bladder being rarely absent. Many epithelia will contain endogenous new-formations, and these are not infrequently seen in the accompanying epithelia from the ureters. Pus-corpuscles and fat-globules in varying numbers, together with mucus-threads, complete the features in these cases.

CARCINOMA

The varieties of cancer developing in the bladder are principally the villous, the epithelial, and the medullary, the first two being more common than the third. Villous or papillary cancer, the so-called cauliflower growth, is probably due in many cases to a secondary malignant change of a previously benign papilloma. This can be proved in those cases in which a tumor, having lasted for years and having always given the characteristics and features of a benign papilloma, becomes changed and assumes the features of malignancy. Such a villous cancer is in reality only a subvariety of an epithelial cancer or epithelioma, but seems to be more frequently seen in the bladder than the regular epithelioma. Medullary cancer, perhaps the most malignant, that is, most rapidly fatal of all cancers, does not often develop in the bladder, and if it does, can hardly be distinguished by an examination of the urine, unless large masses of the tumor are cast off.

Microscopical Features.— The features found in a urinary sediment of a case of villous cancer are depicted in Fig. 103.

At the time this urine was examined, no active hæmorrhage was taking place, therefore red blood-corpuscles were not numerous, though some were present. In different fields, variously sized, dark brown or even black blood-clots were seen, composed of masses of disintegrated blood-corpuscles. Hæmatoidin crystals, in the form of small plates and needles, the latter also seen in small conglomerations, were present, though not abundant.

The connective-tissue shreds found in villous cancer may be even larger and more irregular than those seen in papilloma, not infrequently having the appearance of cauliflower-like excrescences, or containing large bulbs or knobs. These shreds

are always coarsely granular and filled to a greater or less degree with inflammatory corpuscles, more pronounced than in papilloma. Again, a number of these shreds contain large, irregular cancer epithelia, sometimes even small nests, a feature never found in the connective tissue from a papilloma. Capillary blood-vessels, filled with blood-corpuscles, are sometimes found in these shreds, and may pervade their entire length.

The original fibrous structure of the connective-tissue shreds has become changed, and only scanty fibers are present, the shred frequently appearing as a mass of coarsely granular protoplasm. Connective-tissue masses with a pronounced epithelial covering may perhaps occur in the urine in rare cases, but the detached masses from the tumor are usually changed, being broken down more or less completely, so that an epithelial covering is rarely seen.

Besides the epithelia from the middle and deepest layers of the bladder, containing fat-globules and endogenous new-formations, large numbers of irregular, coarsely granular epithelia, partly single, partly in groups, are present; these also contain fat-globules and endogenous new-formations, and are the cancer epithelia. As long as these epithelia are seen alone, without other evidences of cancer, no diagnosis of a malignant tumor can be made, since they can not be differentiated from other epithelia, as, for instance, those found in papilloma. In pronounced cases of cancer, however, variously sized epithelial nests are seen, containing three, four, or more cancer epithelia, and as soon as these are found the diagnosis of a cancer becomes positive, even though the connective-tissue shreds should not be as characteristic as above described. Pus-corpuscles are always present in moderate or large numbers.

Not only can a villous cancer be diagnosed, as just described, but also a regular epithelioma. In such cases the urine may contain epithelial masses showing a pronounced concentric arrangement, and even the fatty degeneration of the epithelia in the center, producing shining, irregular masses of fat,—the so-called cancer pearls,—may be present. All the other features will remain the same.

The positive diagnosis of medullary cancer from the examination of urine is not so easy, though the presence of a cancer of some kind can, as a rule, be made from features similar to those described.

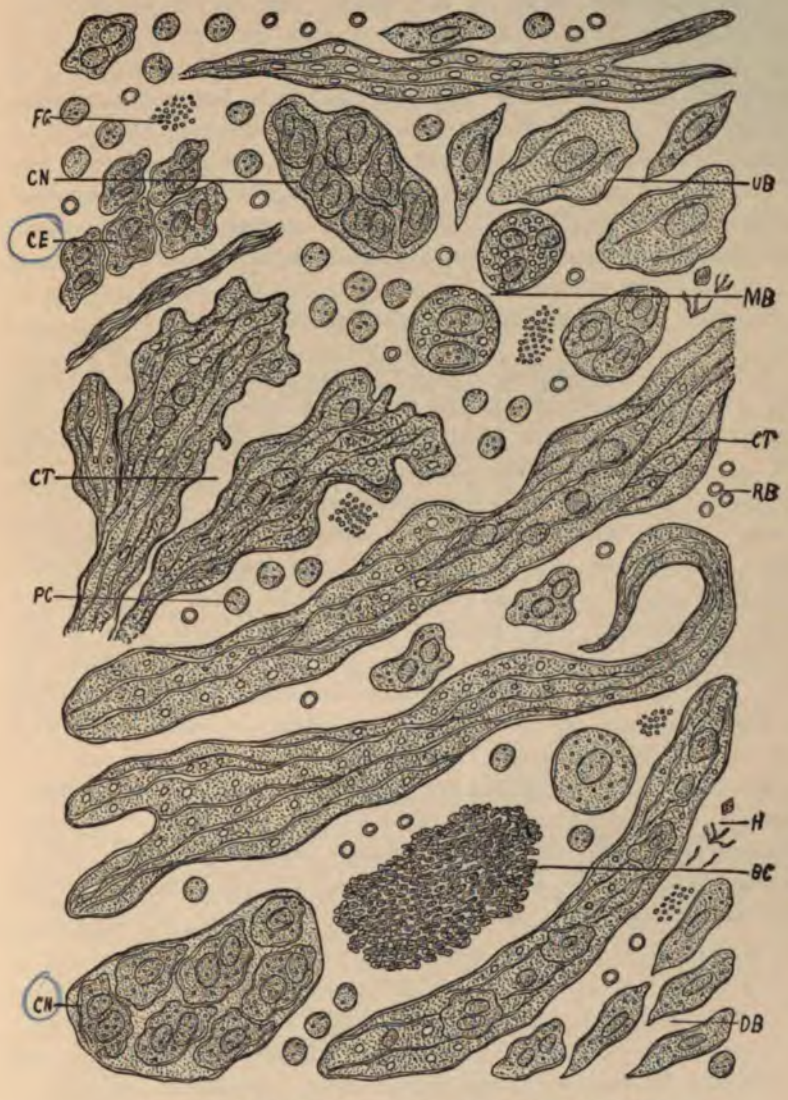

FIG. 103. VILLOUS CANCER OF THE BLADDER (× 500).

RB, red blood-corpuscles; PC, pus-corpuscles; UB, epithelia from the upper layers of the bladder; MB, epithelia from the middle layers of the bladder, containing fat-globules and endogenous new-formations; DB, epithelia from the deepest layer of the bladder; CE, cancer epithelia; CN, cancer nest; CT, connective-tissue shreds; H, hæmatoidin crystals; BC, blood-clot; FG, free fat-globules.

When a tumor in the bladder has existed for some time, secondary inflammations of the ureter, the pelves of the kidneys, and the kidneys frequently develop sooner or later, and may become pronounced. In the kidney, both catarrhal or interstitial and croupous or parenchymatous inflammation may appear. The urine will then show all the features of such an inflammation, in addition to those of the tumor. In the case of a child one year of age, in which a papilloma of the bladder existed, all the features of a subacute croupous nephritis were also found, and the case proved fatal in a short time.

III. *PARASITES IN THE BLADDER*

That a large number of micro-organisms of different kinds may not infrequently be found in the bladder, has already been mentioned. Symptoms of a more or less pronounced cystitis will sooner or later appear in almost all those cases.

Animal parasites are also occasionally found in the bladder, among these being *echinococci*, *actinomyces*, *distoma hæmatobium*, and *filaria sanguinis*, as well as *ascaris lumbricoides*, *strongylus gigas*, and *oxyuris vermicularis*. The diagnosis of these parasites is only possible when either their ova or the parasites themselves can be discovered in the urine. Many of these will invade the bladder only secondarily, being present in other organs, as the kidney or pelvis, or find their way into the bladder through the urethra.

In every case of this kind, either hæmorrhage or inflammations of varying degrees of intensity will sooner or later develop, with all the characteristic features in the urine. Ulcers are often due to such parasites, as, for instance, in the case of actinomycosis of the bladder previously mentioned.

Chapter XVI

DISEASES OF THE SEXUAL ORGANS

Diagnosis of diseases of the sexual organs by microscopical examination of the urine must of necessity be limited; it is not of so great practical importance as in diseases of the urinary organs, since the clinical symptoms are in many cases sufficiently clear. There are, however, cases where the examination of the urine will either corroborate a suspected diagnosis, or will even lead to the clearing up of the case when the clinical symptoms are not plain. This will naturally be of more common occurrence in diseases of the male than of the female tract, in which latter, examination of the patient is, as a rule, sufficient for the diagnosis.

In the male, inflammations of the urethra, the prostate gland, and the seminal vesicles can be diagnosed from urine examination, while in the female those of the vagina are easily diagnosed, and sometimes also those from the cervix of the uterus and the uterine mucosa.

URETHRITIS

Acute Urethritis.—The clinical symptoms of an acute urethritis, whether gonorrhœal or non-gonorrhœal, are so evident that an examination of the urine is never required to clear up the case. When it is examined for other purposes at the time such a urethritis is present, large numbers of urethral epithelia are always found. In the first days of a urethritis the irregular, flat epithelia from the upper layers are more abundant, but soon the cuboidal and columnar epithelia are seen. Pus-corpuscles are present to a varying degree in every case.

Chronic Urethritis.—The symptoms of a chronic urethritis, especially when of a mild character, may be so slight that the urine has to be examined to render the diagnosis certain.

In many of these cases conglomerations of mucus with pus-corpuscles and epithelia—the so-called gleet-threads—are found, even though they are scanty. Under the microscope these

threads (Fig. 37) consist of a varying amount of mucus, both fibers and corpuscles, from the mucous glands of the urethra, pus-corpuscles, which are abundant in the more pronounced, but may be quite scanty in the mild cases, and urethral epithelia, which also vary in number. Besides these features, epithelia from the prostate gland are almost invariably present, and are usually more numerous than the urethral, which latter may at times not be found at all. The larger numbers of pus-corpuscles and epithelia are seen studded with small fat-globules, and these may also be seen upon and between the mucus-threads. If gleet-threads are not present, a small number of the irregular urethral epithelia, with pus-corpuscles, mucus-threads, and prostatic epithelia, are seen in every case of chronic urethritis.

When an ulceration or stricture exists in the urethra, the urine, as a rule, shows some features. In an ulceration, red blood-corpuscles in at least moderate numbers, pus-corpuscles, bacteria—especially the zoöglœa masses—urethral epithelia, mostly the cuboidal and columnar varieties together, and connective-tissue shreds are never absent. As the prostate gland almost invariably becomes involved in these cases, prostatic epithelia are also present.

In stricture of a mild character, small connective-tissue shreds, with a few epithelia from the urethra and prostate gland, and a few pus-corpuscles, are not infrequently seen, although there may be no features whatever in the urine of such cases. The urethral epithelia may have two or even more nuclei.

PROSTATITIS

The diagnosis of a prostatitis from the urine is undoubtedly of greater importance than that of a urethritis, since, especially in the mild chronic cases, the clinical symptoms may not be sufficiently pronounced.

Causes.—The causes of a prostatitis are numerous, though probably the most frequent cause of an acute inflammation is an acute urethritis. The passage of unclean instruments, such as sounds or catheters, injections of chemical agents, or any irritant or injury of whatever kind, such as may be due to horseback or bicycle riding, may cause a prostatitis, as well as simple exposure to cold and wet. In the course of febrile diseases it also develops occasionally.

Chronic prostatitis may be produced by stricture of the urethra, masturbation, excesses in venery, hæmorrhoids, constipation, or by inflammations of the neighboring organs.

Clinical Symptoms.—An acute prostatitis, if severe, may be ushered in by chills and fever, followed by discomfort or pain in the perineal region and frequent micturition. The pain is usually increased upon motion, and the perinæum is found to be sensitive upon pressure.

In chronic prostatitis the symptoms may be slight, the principal one perhaps being the occasional discharge of a small amount of a clear, viscid fluid, constituting the so-called prostatorrhœa; this flow is usually increased upon defecation. Besides this, slight discomfort and tenderness in the perinæum, frequent micturition, and slight pain at the end of urination, may be present. Enlargement of the gland may cause more or less retention of urine.

Features Found in Urine.—The appearance of the urine varies considerably with the intensity of the inflammation, and is not characteristic. In acute cases slight or more pronounced hæmorrhages may take place, and cause the urine to assume a darker color; when considerable pus is present it will be more or less turbid, and also contain a varying amount of albumin. In mild chronic cases the urine may be perfectly clear.

When such a urine is examined for albumin, it must not be forgotten that whenever pus-corpuscles and red blood-corpuscles are present albumin will always be found, its amount depending upon the amount of pus and blood, so that in cases of abscesses or hæmorrhages the urine will contain considerable albumin, and faint traces will never be absent when there is any inflammation of the prostate gland. It is evident, therefore, how important a microscopical examination of the urine becomes in all these cases, since such an examination alone will determine whether the kidneys are inflamed, and this be the source of albumin, or whether the albumin is due simply to the prostatitis.

Acute Prostatitis.—In an acute prostatitis of moderate severity, the features found in the urinary sediment are red blood-corpuscles in varying numbers, pus-corpuscles, mucus, and epithelia from the prostate gland. Red blood-corpuscles are never absent in an acute inflammation, and are numerous when hæmorrhages occur, as is sometimes the case. Pus-corpuscles vary in number according to the degree of intensity of the

inflammation. Mucus, in the form of threads and corpuscles, is always increased, and may be present in large amount.

The characteristic features of a prostatitis are the epithelia. The prostate gland is lined by several layers of cuboidal epithelia, while the duct of the gland contains columnar epithelia. The cuboidal epithelia are always twice as large as the pus-corpuscles and larger than those from the convoluted tubules of the kidney. They have the same size as the cuboidal epithelia from the ureters, and when they are present alone, without the columnar epithelia from the duct, the comparative number of these, with those of the kidney and pelvis of the kidney, must be taken into consideration. An inflammation of the ureters is almost invariably secondary to a nephritis or pyelitis, and when the epithelia from the kidney or pelvis, or both, are seen, together with a small number of those twice the size of the pus-corpuscles, they are always ureteral. The absence of symptoms of a pyelo-nephritis, but the presence of a varying number of cuboidal epithelia double the size of pus-corpuscles, would show that they are from the prostate gland. Since a prostatitis, especially when it has lasted for some time, may cause a secondary inflammation of the bladder, the ureters, pelvis of the kidney and kidney, epithelia from all these organs may be present, and here not only the comparative number, but also the clinical symptoms of the case, will have to be taken into consideration to determine the positive source of the epithelia.

On the other hand, in an inflammation of the prostate gland, the columnar epithelia from the duct of the gland are almost invariably present with the cuboidal epithelia in moderate or even large numbers, while the columnar epithelia from the ureters are rarely seen, and then in small numbers only. The columnar epithelia from the pelvis of the kidney, although they vary in size to a certain degree, are always somewhat larger than those from the duct of the prostate gland and more irregular, so they cannot be mistaken for the latter.

A prostatitis is in most cases associated with inflammation either of the urethra or of the bladder (especially the neck), or both, and the epithelia from these organs will then be associated with those from the prostate gland. Severe cases, will, as already mentioned, be ascending in character, producing a pyelitis and finally a nephritis, with all the accompanying features of the same.

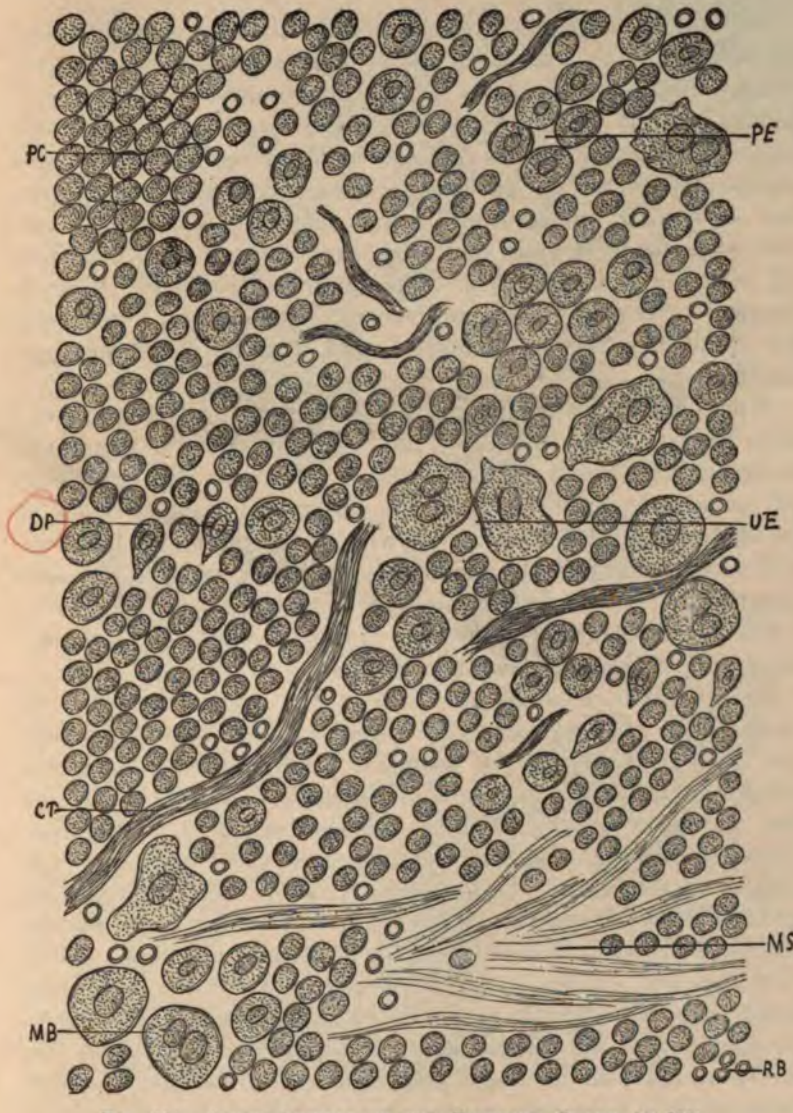

FIG. 104. ACUTE ABSCESS OF THE PROSTATE GLAND (× 500).

RB, red blood-corpuscles; PC, pus-corpuscles; PE, epithelia from the prostate gland; DP, epithelia from the duct of the prostate gland; UE, epithelia from the urethra; CT, connective-tissue shreds; MS, mucus-threads; MB, epithelia from the middle layers of the bladder.

Acute suppurative prostatitis, or abscess of the prostate gland, is of common occurrence, and its features are illustrated in Fig. 104.

We see here red blood-corpuscles in moderate numbers, and pus-corpuscles in extremely large amount, which not infrequently fill up entire fields of the microscope. Cuboidal epithelia from the prostate gland, as well as columnar epithelia from the duct, are always present in these cases, and are not infrequently found in groups. Connective-tissue shreds are seen in varying numbers, and unless they are found, the diagnosis of an abscess must never be made, even if pus-corpuscles and epithelia are numerous. The latter is the chief point of distinction between a severe, but non-suppurative, prostatitis and an acute abscess. Mucus-threads may be found in large numbers.

When a suppurative prostatitis is the result of a urethritis, which is frequently the case, the irregular epithelia from the urethra will be found accompanying the features just described, and, as a rule, epithelia from the upper and middle layers of the bladder are also present, showing a cystitis. In both the urethral epithelia and the bladder epithelia an endogenous new-formation of pus-corpuscles may be seen.

Chronic Prostatitis.—Chronic prostatitis will give characteristic features under the microscope (Fig. 105).

Red blood-corpuscles are here either entirely absent or scanty, and pus-corpuscles are present in moderate numbers only. Cuboidal as well as columnar epithelia from the prostate gland and its duct are quite abundant, the former being often found in groups of four, five, or more. Both the pus-corpuscles and the epithelia are studded with glistening fat-globules and -granules, which latter also lie free. In the case from which the illustration was drawn, this fatty change was extremely pronounced—more so than is usually the case. Every epithelium and almost every pus-corpuscle was filled with these globules, giving the whole corpuscle a glistening appearance. The free groups of fat-globules were numerous and large, the individual globules in many groups being of considerable size. Mucus-threads were seen in moderate numbers, but connective-tissue shreds were absent.

In this case no urethral epithelia were seen, but the accompanying cystitis was pronounced, so that the epithelia from the

FIG. 105. CHRONIC PROSTATITIS (× 500).

PC, pus-corpuscles, containing fat-globules; PE, epithelia from the prostate gland, containing fat-globules; DP, epithelia from the duct of the prostate gland, containing fat-globules; MB, epithelia from the middle layers of the bladder; NB, epithelia from the neck of the bladder; MS, mucus-threads; FG, free fat-globules.

bladder were quite abundant. Not only the regular cuboidal epithelia from the middle layers of the bladder, studded with fat-globules, were present, but also larger epithelia from the neck of the bladder. Mention should here be made of the fact that the epithelia from the neck of the bladder are usually larger than those found in the other portions of the bladder, and may even attain the size of vaginal epithelia. These large epithelia are, however, never numerous, are seen only with the other features, and are not studded with bacteria, as is almost invariably the case in the epithelia from the upper layers of the vagina.

Hypertrophy of the prostate gland may give characteristic features in the urine, even before the clinical symptoms are sufficiently pronounced to lead to a suspicion of the affection. In these cases all the features of a chronic prostatitis are found, usually with a small or moderate number of pus-corpuscles only, but with small connective-tissue shreds, which in many cases are scanty. If the latter are seen with all the evidences of a chronic prostatitis, especially when the age of the patient is above forty or forty-five years, the diagnosis of hypertrophy can be made. When the hypertrophy becomes more pronounced, the endogenous new-formation will be seen in the larger numbers of epithelia from the middle layers of the bladder. In these cases, prostatic concretions, previously described, are not rarely found.

Tuberculosis.—Tuberculosis of the prostate gland is probably never present alone without an involvement of the neighboring organs, and is a comparatively rare affection. It will always give the symptoms of a prostatitis or an abscess of the prostate gland with a considerably impaired constitution, as shown by the pale, finely granular pus-corpuscles. When it is suspected, repeated examinations for tubercle bacilli must be made.

Tumors—Tumors of the prostate gland are also of rare occurrence, but both sarcoma and cancer are met with, and can be diagnosed from the urine. In sarcoma, the characteristic small, glistening bodies previously described, with large connective-tissue shreds, and the evidences of a chronic prostatitis are seen; while in cancer the connective-tissue shreds and epithelia, described in cancer of the bladder, may be found in the urine. The clinical symptoms must of necessity help the microscopical examination in many of these cases.

SPERMATORRHŒA

Spermatorrhœa, which in young men is by no means rare, and consists in an occasional involuntary flow of semen, especially at the end of defecation, or even upon urination, can not infrequently be diagnosed from the urine.

When a urine is to be examined to prove the presence of a spermatorrhœa, it is best to take either the first urine voided in the morning, or the last quantity voided during defecation. In such a urine the elements of the sperma, with spermatozoa in large numbers, will be found. In almost all these cases a prostatitis of varying degrees of intensity will exist and give the features under the microscope.

Whenever a prostatitis is found in young men in whom no other cause can be discovered, a suspicion of spermatorrhœa must arise, even when no spermatozoa are seen in the urine first examined. Repeated examinations will invariably show these, and render the diagnosis positive. The clinical symptoms of a chronic prostatitis—that is, an occasional discharge of a clear, viscid fluid, especially in younger men,—may not infrequently lead to the mistaken diagnosis of spermatorrhœa, which disease must never be diagnosed without the evidence of a discharge of sperma.

Besides the prostatic epithelia, those from the ejaculatory ducts may also be seen in the urine. Mucus is always present in these cases in large amount, and mucus-casts or cylindroids may be abundant. Care must be taken not to mistake these for regular hyaline casts from the uriniferous tubules of the kidney, which they sometimes resemble to a marked degree; sharp focusing will always bring out the pale fibers of mucus, thus proving that they are not hyaline casts.

SEMINAL VESICULITIS

Seminal vesiculitis or spermatocystitis has received considerable attention of late years by many authors, who all agree that the affection is of much more common occurrence than has been supposed. Although frequently of gonorrhœal origin, this is not the exclusive cause of the disease, and Fuller claims that in about one-third of the cases it is tubercular in character. It may also be catarrhal in origin, though most authors believe that the non-gonorrhœal cases are rare.

Clinical Symptoms.—The symptoms of a spermatocystitis are not always well pronounced, and, therefore, may escape detection for years. Disturbances of the sexual functions are most constant, though they vary in different cases. In many there is a marked increase of sexual desire, but no relief is afforded by the coitus. This is, however, not present in every case, and in some there is a diminution or even absence of the desire. Pain may be present in the perinæum and upon urination, and there may even be tenesmus. In many cases an intermittent or even constant discharge from the urethra, which is sometimes quite profuse, is present, and some patients will complain of bloody emissions.

It will be seen that neither one of these symptoms is at all characteristic, and rectal examination must be resorted to. This is sometimes successful, but in many cases is not; when the seminal vesicles can be reached, they will be found distended and tender to the touch. A positive diagnosis can only be reached by a microscopical examination, and the seminal fluid will, in all these cases, contain pus-corpuscles, and usually, especially in acute cases, red blood-corpuscles.

Features Found in Urine.—The microscopical examination of the urine will often clear up the case, provided seminal fluid is found in it. The early morning urine, especially the part first voided, or the last urine passed at defecation is best for this purpose. The features found in seminal vesiculitis are illustrated in Fig. 106.

Spermatozoa are here found in large numbers. Some of them have the normal appearance, but the larger number are changed. The change takes place in the head of the spermatozoön, which becomes larger, round, and granular, and finally has the appearance of a pus-corpuscle, so that we seem to see pus-corpuscles with tails in such a urine. This change is characteristic of the disease, and is invariably seen, though not always as pronounced as here shown. The originally oval head first becomes rounded and then somewhat enlarged and granular. In milder cases a further enlargement will take place in a few spermatozoa only, while in the more pronounced cases many assume the size of pus-corpuscles, being either coarsely or finely granular.

Besides the spermatozoa, pus-corpuscles are always found in such a urine, and may be either scanty or numerous, according to the degree of inflammation. Since suppuration not infrequently

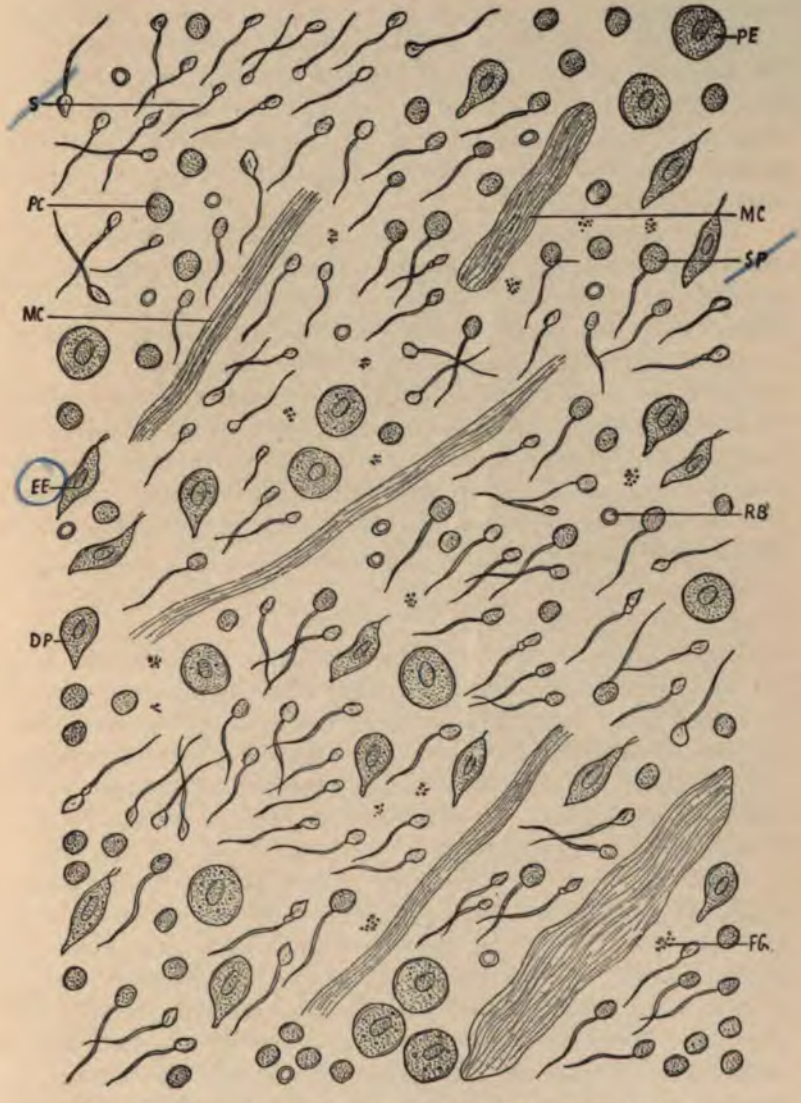

FIG. 106. SPERMATOCYSTITIS OR SEMINAL VESICULITIS (× 500).

PC, pus-corpuscles; RB, red blood-corpuscles; S, spermatozoa; SP, spermatozoa, heads appearing like pus-corpuscles; EE, epithelia from the ejaculatory duct; PE, epithelia from the prostate gland; DP, epithelia from the duct of the prostate gland; MC, mucus-casts; FG, free fat-globules.

occurs in the seminal vesicle, pus-corpuscles may be very numerous. Red blood-corpuscles are almost always present, though their number also varies considerably, being abundant in the more pronounced and scanty in the milder or the chronic cases.

Epithelia from the ejaculatory duct can always be found. These are originally columnar ciliated epithelia, and in some the cilia will be seen, while in others they are broken off. When they are broken, delicate parallel rods in the interior of the epithelia, near their basal surfaces, may indicate that the epithelia were originally ciliated.

In all cases examined, epithelia from the prostate gland were present, showing that the prostate gland was also inflamed. The numbers of prostatic epithelia will, however, vary considerably, though they are usually fairly abundant, both the cuboidal and columnar epithelia being seen. In the more chronic cases fat-globules are found, both in the epithelia and lying free. Mucus is always greatly increased in these cases, and cylindroids or mucus-casts may be numerous; the mucus-threads sometimes assume large sizes. When suppuration exists, connective-tissue shreds are always present. Epithelia from the urethra and the bladder may accompany the other features.

VAGINITIS

Inflammations of the vagina, especially mild chronic cases, are of common occurrence, and have little significance, the only symptom being a slight discharge; few women who have borne children are entirely free from this affection. The severer cases may be due to many causes, such as exposure to cold, gonorrhœal infection, or injuries of any kind, or may be secondary to an inflammation of the uterus.

Features Found in Urine.—It is rare that in the urine of a female vaginal epithelia are not found in greater or less amount. Epithelia from the upper layers are shed in a small amount in perfect health, and have no significance; such epithelia may be seen even in small children. So long as the flat epithelia from the upper layers are present alone in small numbers, without cuboidal epithelia from the middle layers and without pus-corpuscles, the diagnosis of a vaginitis can not be made. As soon, however, as large cuboidal epithelia are also present, a pathological process of some kind exists in the vagina.

Catarrhal Vaginitis.—The common forms of vaginitis seen

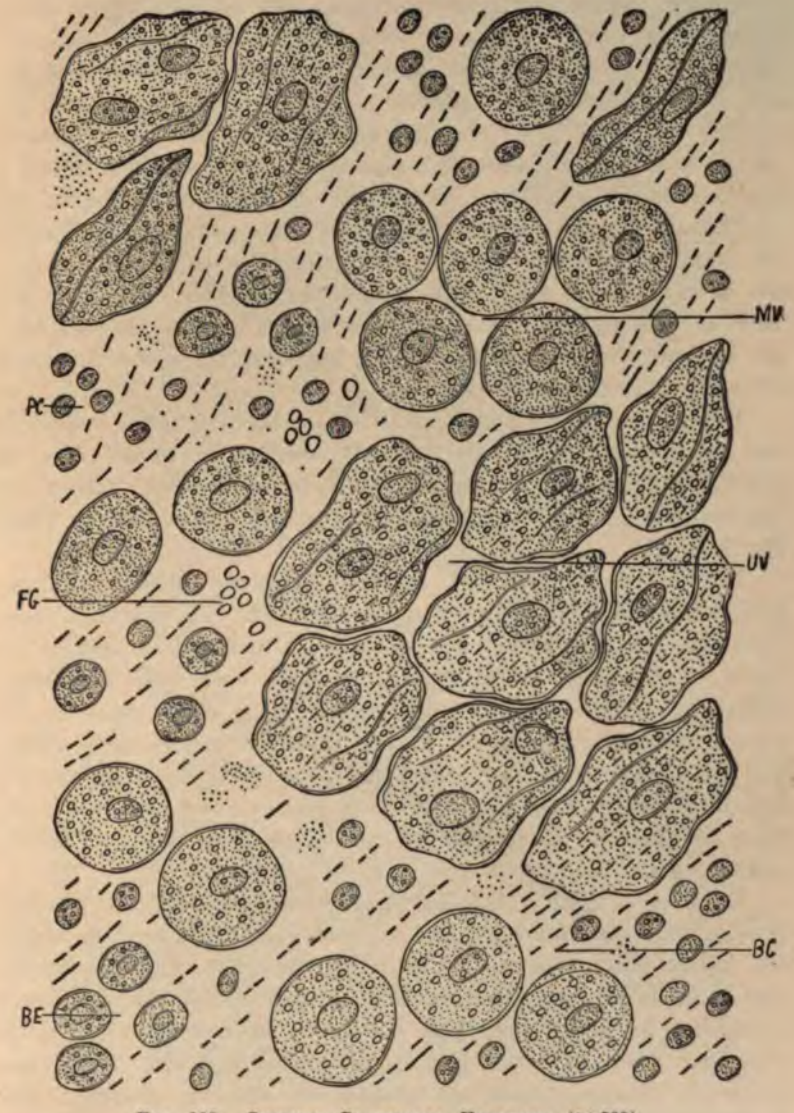

FIG. 107. CHRONIC CATARRHAL VAGINITIS (× 500).

PC, pus-corpuscles; UV, epithelia from the upper layers of the vagina; MV, epithelia from the middle layers of the vagina, containing fat-globules; BE, epithelia from the Bartholinian gland; FG, free fat-globules; BC, bacilli and cocci.

in the urine are the mild chronic cases, and the features found are shown in Fig. 107.

Pus-corpuscles are always present, but usually in small numbers only. Epithelia from the upper and middle layers of the vagina are quite numerous. These epithelia are considerably larger than those from the bladder, the upper layers being flat, the middle cuboidal. Epithelia from the upper layers are frequently studded with bacilli and cocci, and often contain variously sized extraneous fat-globules. They may be found in groups, which may fill the greater part of the field. Cuboidal epithelia from the middle layers, which in urine usually appear round or oval, though they vary in size sometimes to a great degree, are always larger than those from the bladder, and may also be found in groups. Columnar epithelia from the deepest layer are not seen in these milder cases, but only in severe inflammations or ulcerations.

Besides these epithelia, small cuboidal epithelia, twice the size of pus-corpuscles and exactly similar to those from the prostate gland in the male, are usually present; these are the epithelia from the Bartholinian gland and denote a slight Bartholinitis.

Pus-corpuscles, as well as the different epithelia, contain small fat-globules in varying numbers in all chronic cases. Free fat-globules may also be seen. In most, if not in all cases of vaginitis, micro-organisms, both cocci and bacilli, are found, and are, as a rule, quite abundant. Their presence has no significance, as it is well known that micro-organisms always exist in the vagina, the more pronounced if an inflammation has developed. The characteristics here described are usually seen in urines examined for other reasons and containing other features.

In acute vaginitis red blood-corpuscles as well as pus-corpuscles will be abundant, and vaginal epithelia from the different layers quite numerous. In plain catarrhal vaginitis the flat and cuboidal epithelia are usually present alone, while in vaginitis due to gonorrhœa, and especially in ulcerative vaginitis, columnar epithelia from the deepest layer are also found, and connective-tissue shreds are present in varying amount. Epithelia from the Bartholinian gland are rarely absent, and when a suppurative inflammation sets in, as is often the case in gonorrhœal infection, are very abundant.

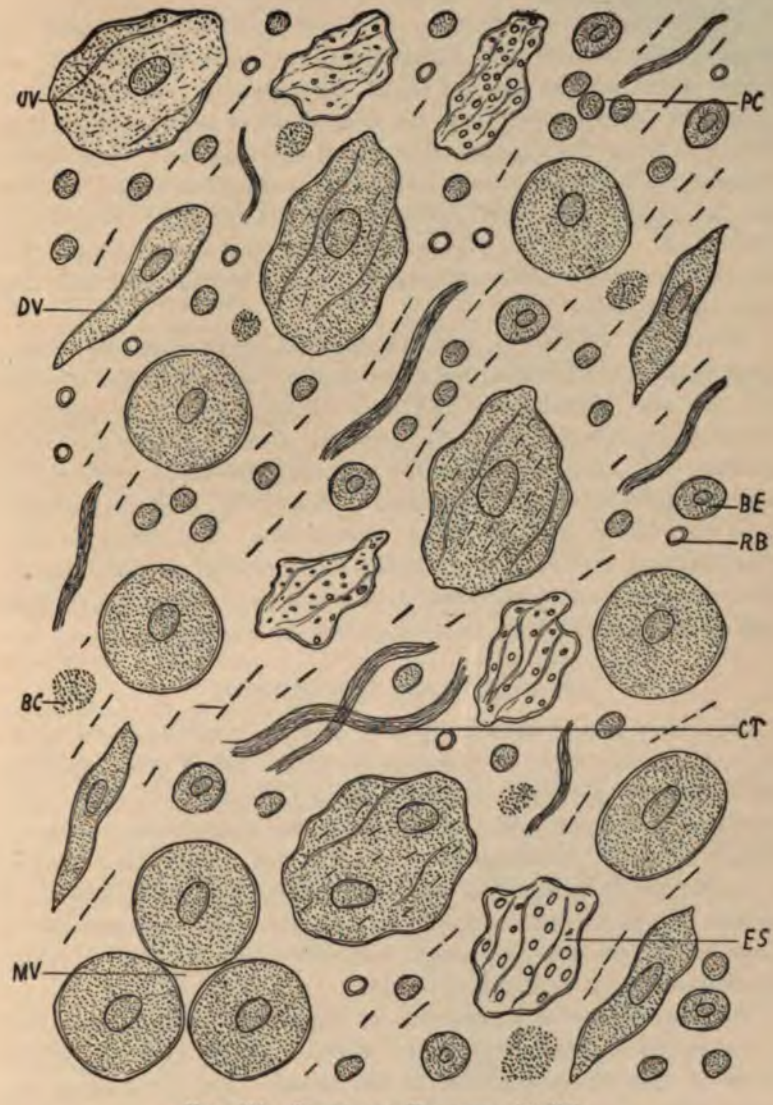

FIG. 108. TRAUMATIC VAGINITIS (× 500).

RB, red blood-corpuscles; PC, pus-corpuscles; UV, epithelia from the upper layers of the vagina; MV, epithelia from the middle layers of the vagina; DV, epithelia from the deepest layer of the vagina; ES, epidermal scales; BE, epithelia from the Bartholinian gland; CT, connective-tissue shred; BC, bacilli and cocci.

Traumatic Vaginitis.—Traumatic vaginitis can also be diagnosed from the urine. The features found in traumatic vaginitis, due to masturbation, are shown in Fig. 108.

Pus-corpuscles are present in small numbers only, and red blood-corpuscles are not numerous; but epithelia from all the layers of the vagina are abundant, the cuboidal from the middle layers and the columnar from the deepest layer being well marked. Epithelia from the Bartholinian gland are also seen in moderate numbers. Epidermal scales, showing corrugated edges, studded with fat-globules and dirt-particles, and not granular, are seen in every field. Connective-tissue shreds are also seen, though they are not numerous. Micro-organisms and a few fat-globules complete the features.

Whenever epithelia from the deepest layer and connective-tissue shreds are present, we have all the evidences of a destructive process. Continuous irritation or injury to the parts by masturbation is sufficient to produce these features in small numbers. If an ulcer exists, the pus-corpuscles and epithelia are more numerous, and if traumatism results in hæmorrhage, red blood-corpuscles will be more abundant. The features here described may be found accidentally when a urine is examined for other pathological conditions, and when seen in that of young girls should always lead to a suspicion of masturbation.

CERVICITIS AND ENDOMETRITIS

Cervicitis and endometritis may also be diagnosed from the urine, when the different epithelia from the cervix and mucosa of the uterus are present. Epithelia from the cervix uteri are quite large and irregular, while those from the mucosa uteri are columnar ciliated. Both are shown in Fig. 101. The other features of such an inflammation are the same. In ulcerations or injuries shreds of connective-tissue are seen. In endometritis we occasionally find pus-corpuscles with cilia from the mucosa uteri, together with the ciliated epithelia.

Tumors from the uterus can be diagnosed from examination of the urine in rare cases only, when a small particle of the tumor is cast off and found in the urine. The features of the tumor will be the same as previously described, and the epithelia will determine the seat of the tumor.

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